MARINE REVIEW

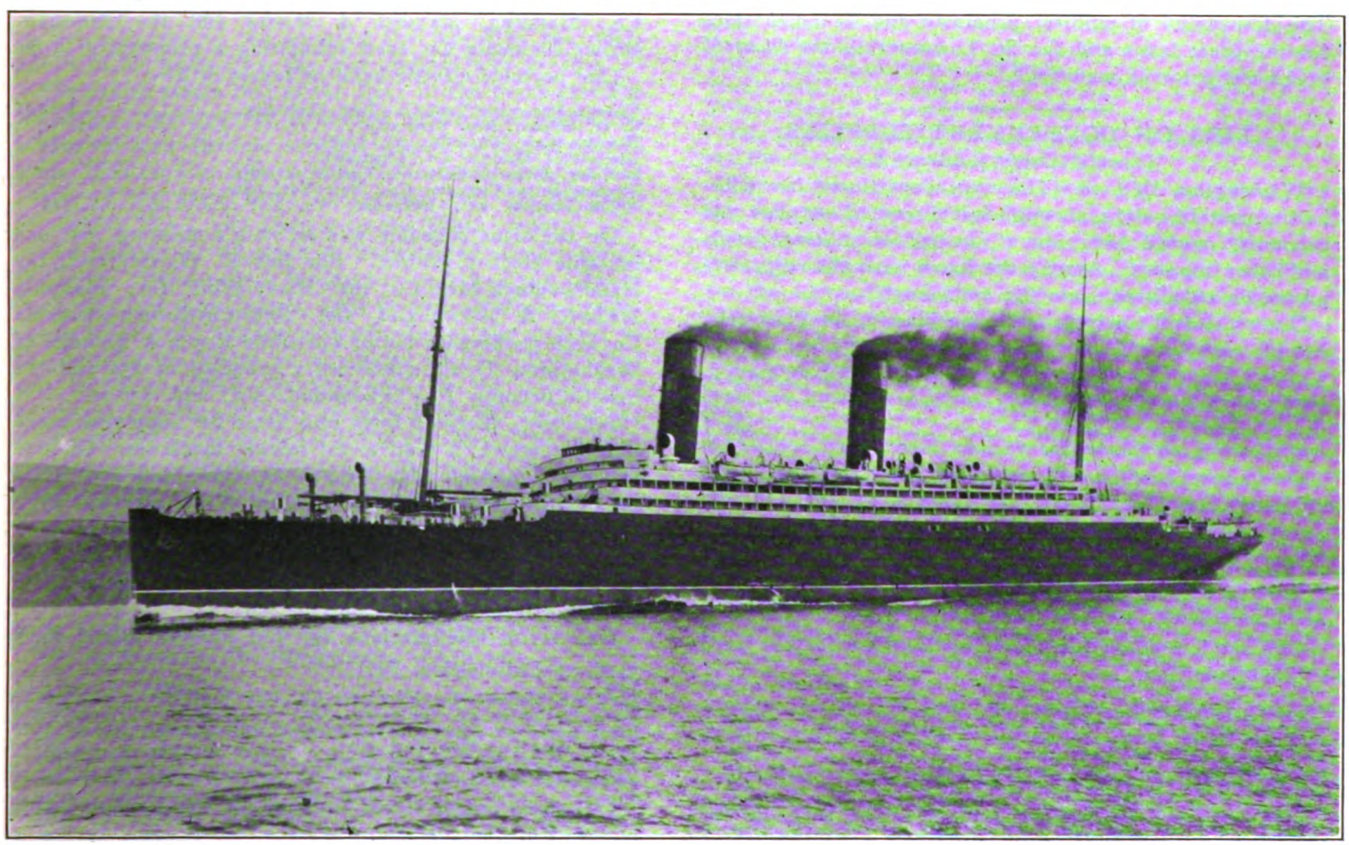
VOL. XXXII. CLEVELAND, DECEMBER 21, 1905. No. 25.

REPORT ON STEAMBOAT INSPECTION SERVICE.

Secretary Victor H. Metcalf, of the department of commerce and labor, in his reference to the steamboat inspection service, says that during the year there were carried 342,260,350 passengers on steamers required by law to make report of such number of passengers, and estimating that there were carried at least 250,000,000 more on steamers not required to make such report, it can be safely calculated that nearly 600,000,000 passengers were carried by steamers under the jurisdiction of this service. With this number an average of one life was lost for every 2,390,438 passengers carried. The secretary adds:

"Consequent upon the disaster to the General Slocum, and as the result of a careful study of the conditions of the service carried on by the department since the last report, it became clear that both the statutes and the rules and regulations governing the construction, equipment, maintenance and operation of steamboats required considerable revision and strengthening. A number of bills covering the subject were therefore prepared and submitted to congress, most of which were duly enacted. By far the most important change was that in the salary system, for the pay of local inspectors.

"Under the old system, as provided by statute, the inspectors were paid according to the number of vessels inspected and passed. A substantial premium was thus actually placed on lax inspection, and the change to a fixed



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salary for each inspector, regardless of the number of vessels inspected, was a most salutary one. A special meeting of the board of supervising inspectors was held in December, 1904, and they submitted to the secretary for his approval an entire preliminary revision of the rules and regulations. Public notice of the proposed changes was widely given and a public hearing was held in the office of the secretary on Jan. 16, 1905, at which nearly all the maritime interests of the country were represented. After this hearing nearly two months additional were devoted to these rules both by the board and by various officials of the department, with the aid of outside experts on technical subjects, and as a result an entirely new body of rules and regulations was passed by the board and approved by the secretary March 11, 1905, and has since been in operation.

"As a further measure of safety, and with a view also to determining the general condition of the service the reinspection of steamers, with the aid of officers detailed from the navy department, was completed and showed in detail the conditions in all the more important districts. A further inspection, ordered in September, 1905, and made by the service itself, showed a great improvement in the condition of vessels generally, and indicated that the work of the service, with few exceptions is careful and efficient.

"The revised Canadian rules for preventing collisions of vessels on the great lakes and connecting and tributary waters as far east as Montreal went into effect last April. These rules are substantially the same as the American rules approved Feb. 8, 1895, for the same waters. The desirability of uniform American and Canadian rules for the great lakes and the St. Lawrence to the head of ocean navigaton is manifest."

BIDS ON GOVERNMENT SUPPLIES.

(Special Correspondence.)

Washington, Dec. 18.—The navy department has within the past few days, through its bureau of supplies and accounts, opened bids for a number of machine tools and other supplies. Among the items with the respective proposals submitted were the following:

One twist drill emery grinding machine for the Pensacola, Florida, navy yard.

Baird Machinery Co., Pittsburg	$61.90 and $ 64.60
Handlan-Buck Mfg. Co., St. Louis	66.50
Royce & Ricketts, Washington, D. C.	63.00
Wm. Sellers & Co., Philadelphia	220
Smith-Courtney Co., Richmond, Va.	74.00

One engine and screw-cutting lathe for the navy yard at Pensacola, Florida:

Garvin Machine Co., New York city	$462
Hendey Machine Co., Torrington, Conn.	650
Le Blond Machine Tool Co., Cincinnati	520.34
Niles-Bement-Pond Co., New York city	509.50
Royce & Ricketts, Washington, D. C.	575
Smith-Courtney Co., Richmond, Va.	659

One single spindle edge molding machine for the yard at Pensacola, Fla.

American Woodworking Machinery Co., New York	$166.65
Baird Machinery Co., Pittsburg	176
Drew Machinery Agency, Manchester, N. H.	149.60
Fay & Egan Co., New York city	172
Oliver Machinery Co., Grand Rapids, Mich.	175
Smith-Courtney Co., Richmond, Va.	140

One improved pipe-cutting and threading machine for the Pensacola, Florida, navy yard.

Baird Machinery Co., Pittsburg	$734
Walter H. Foster Co., New York city	800
Garvin Machinery Co., New York city	500
Handlan Buck Mfg. Co. St. Louis	$952 and 860
Manning, Maxwell & Moore, New York city	876
Royce & Ricketts, Washington, D. C.	534

For one motor driven band sawing machine for the New York navy yard, the Fay & Egan Co., of New York city was the only bidder, its proposal being $1,525. The same firm submitted the only proposal for one log jack, also for the New York navy yard, their quotation in this instance being $238.

One pattern and core box machine for the Norfolk, Va., navy yard.

Baird Machinery Co., Pittsburg	$189.95
Fay & Egan Co., New York city	504
Manning, Maxwell & Moore, New York city	200
Smith-Courtney Co., Richmond, Va.	192.98

Fay & Egan Co., New York, was the only bidder for three items of equipment for the Pensacola, Florida, navy yard. For furnishing one electric driven band saw they submitted a bid of $944; for one electric driven automatic cut-off the proposal was $1,590 and for one electric driven self-feeding rip saw it filed a bid of $842.

For one open side extension planer for the Boston, Mass., navy yard, the only bid submitted was that of the Detrick & Harvey Machine Co., of Baltimore, Md., which offered to meet the specifications for $6,315.

Twelve pneumatic drills for the New York navy yard.

Chicago Pneumatic Tool Co., New York city	$ 901
Independent Pneumatic Tool Co., Chicago	1,450
Ingersoll-Sargeant Drill Co., New York city	915
Rand Drill Co., New York city	975
Standard Railway Equipment Co., St. Louis	880

For the New York navy yard one portable electric internal grinder—

R. W. Geldart, New York city	$ 96
Hisey-Wolf Machine Co., Cincinnati	96
Manning, Maxwell & Moore, New York city	96
Sherman-Brown-Clements Co., New York city	96

In the proposals for one portable radial drill for the New York navy yard the same uniformity of bids prevailed, the firms of R. W. Geldart, Hisey-Wolf Machine Co., Manning, Maxwell & Moore and the Sherman-Brown-Clements Co. each submitting a proposal of $190.

One portable electric hand or breast drill—

Chicago Pneumatic Tool Co., New York city	$ 63.75
R. W. Geldart, New York city	72
Handlan-Buck Mfg. Co., St. Louis	70
Hisey-Wolf Machine Co., Cincinnati	72
Manning, Maxwell & Moore, New York city	72
Sherman-Brown-Clements Co., New York city	72
Smith-Courtney Co., Richmond, Va.	65

On the same schedule was an item consisting of one portable electric grinder. For this R. W. Geldardt, the Handlan-Buck Mfg. Co., the Hisey-Wolf Co., Manning Maxwell & Moore and the Sherman-Brown-Clements Co. each proffered a bid of $40 while Royce & Ricketts of Washington, D. C., submitted a proposal of $50 and the Smith-Courtney Co., Richmond, Va., bid $37.40.

Bids were received from two firms for supplying three different styles of cold metal sawing machines. On one the Handlan-Buck Mfg. Co., of St. Louis bid $358 while the Vandyck-Churchill Co. of New York city bid $375. On the second the Handlan-Buck Co. bid $258 as compared with $275 bid by the Vandyck-Churchill Co., and on the third the Handlan-Buck bid was $130 against $150 the bid of the Vandyck-Churchill Co.

One scroll saw machine for the League Island navy yard, at Philadelphia, Pa.

American Woodworking Machinery Co., New York city	$ 87.50
Baird Machinery Co., Pittsburg	72.75
Drew Machinery Agency, Manchester, N. H.	83.50
Fay & Egan Co., New York city	99
Handlan-Buck Mfg. Co., St. Louis	105
Smith-Courtney Co., Richmond, Va.	72.59

One 2,500 pound steam hammer for the League Island navy yard, Philadelphia.

Alliance Machine Co., Alliance, O.	$2,570
Baird Machinery Co., Pittsburg	1,879
Erie Foundry Co., Erie, Pa.	2,196
Fairbanks Co., New York city	2,245
Manning, Maxwell & Moore, New York city	1,800
Morgan Engineering Co., Alliance, O.	2,045
Niles-Bement-Pond Co., New York city	1,694
Prentiss Tool & Supply Co., New York city	1,880
Royce & Ricketts, Washington, D. C.	1,850
Wm. Sellers & Co., Philadelphia	$1,880 and 1,955
Vandyck Churchill Co., New York city	2,246
Vermilye & Power Co., New York city	1,886

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On other hammers for the League Island yard there were only two bidders in each instance. For the 150 pound power hammer the Fairbanks Co. bid $725, while Royce & Ricketts, of Washington, D. C., offered proposals on different styles at $850, $1,020, $955, $960, $1,130 and $1,065 respectively. For the one 100 pound power hammer the Fairbanks bid was $640, while Royce & Ricketts submitted proposals of $610, $705 and $685. For the 50-pound hammer Fairbanks Co. bid $525, and Royce & Ricketts $463, $550 and $540.

One centering machine for the League Island navy yard:

Baird Machinery Co., Pittsburg	$222
Fairbanks Co., New York city	210
Pratt & Whitney, Hartford, Conn	281
Vandyck-Churchill Co., New York city	234

One screw-cutting gap lathe for the Norfolk, Va., navy yard.

Manning, Maxwell & Moore, New York city	$723
Niles-Bement-Pond Co., New York city	$453 and 875
Prentiss Tool & Supply Co., New York city	535

One universal milling machine for the Norfolk navy yard.

Aumen Machinery & Supply Co., Baltimore, Md	$800
Becker-Brainard Milling Machine Co., Hyde Park, Mass	550
Brown & Sharpe Mfg. Co., Providence, R. I	$542 and 692.75
Baird Machinery Co., Pittsburg	$744
Fairbanks Co., New York city	643
Hendley Machine Co., Torrington, Conn	$630 and 680
Manning, Maxwell & Moore, New York city	640
Niles-Bement-Pond Co., New York city	585
Royce & Ricketts, Washington, D. C	560
Smith-Courtney Co., Richmond, Va	557

ANNUAL REPORT OF LIFE SAVING SERVICE.

Gen. Supt. Kimball of the life-saving service has transmitted to the secretary of the treasury the report of the operations of his bureau for the year ending June 30, 1905.

The report states that at the close of the fiscal year the life-saving establishment comprised 277 stations, embraced within thirteen districts and distributed by coasts as follows: 200 on the Atlantic and Gulf coasts, sixty on the coasts of the great lakes, one at the falls of the Ohio, (Louisville, Ky.), and sixteen on the Pacific coast.

The number of disasters to documented vessels within the scope of the service during the year was 365. There were on board these vessels, 4,089 persons, of whom twenty-seven were lost. Succor was afforded at the stations to 624 persons, to whom an aggregate of 1510 days' relief was furnished. The estimated value of the vessels was $7,735,300, and that of their cargoes $2,585,360, making the total value of property imperiled $10,320,660. The estimated value of property saved was $7,917,385; of property lost $2,403,275. Sixty-three vessels were totally lost. Four hundred and twenty casualties were sustained by undocumented vessels—sailboats, rowboats, etc.—involving 955 persons, of whom ten were lost. The value of property involved in these casualties is estimated at $264,690; of property saved $258,025; of property lost $6,665.

The aggregate of the foregoing is as follows:

Number of disasters	785
Number of vessels totally lost	63
Number of persons involved	5,044
Number of persons lost	37
Number of persons succored at stations	624
Number of days' succor afforded	1,510
Value of vessels involved	$7,997,225
Value of cargoes	$2,588,125
Total value of property involved	$10,585,350
Value of property saved	$8,175,410
Value of property lost	$2,409,940

The life-saving crews saved and assisted in saving 464 imperiled vessels and their cargoes, besides affording assistance of more or less importance to 677 other vessels, including craft of all kinds, making a total of 1141 vessels to which aid was furnished. In addition, eighty-three steamers and eighty-eight sailing vessels running into danger were warned of their peril by the signals of the patrol and lockout in time to escape disaster; 157 of these warnings being given in the night and fourteen during the day in thick weather. Many lives and much property was undoubtedly thus saved from destruction, but it is manifestly impossible to estimate in figures the services of the station crews in this regard.

While it is primarily the province of the service to save and succor the shipwrecked, a considerable number of persons not connected with vessels are annually rescued from various situations involving imminent peril of their lives. There were 107 cases of this character during the year. Twenty-seven persons had fallen from wharfs, piers, bridges, etc., seven were in bathing, fifty-two were cut off from land by water, seven were in burning dwellings, three had attempted suicide by drowning, two were lying on railroad tracks intoxicated; one was frostbitten and unconscious on the beach, two were lost on the ice in a thick fog, two were in runaway accidents, one was suffering from a severe hemorrhage, one was bitten by a rattlesnake, and two were on board a locomotive that had plunged through an open draw.

The report also contains a tabular statement of the operations of the service from November 1, 1871 (the date of the introduction of the present system), to the close of the last fiscal year, as follows:

Total number of disasters	15,631
Total number of persons involved	111,056
Total number of lives lost	1,098
Total number of persons succored at stations	18,930
Total number of days' succor afforded	46,828
Total value of vessels involved	$161,023,500
Total value of cargoes	$66,619,059
Total value of property involved	$227,642,559
Total value of property saved	$179,758,512
Total value of property lost	$47,884,047

The expenditures for the maintenance of the service during the year aggregated $1,799,644.32.

The recommendation in the report of the preceding year for the enactment of legislation giving pensions to the widows and children of members of life-saving crews losing their lives in the performance of duty, and providing for the retirement of those who become disabled from injury or disease incurred in the service, or from the infirmities of age, is earnestly renewed. In advocacy of the retirement feature the general superintendent, after calling attention to the arguments set forth in last year's report, says:

"The service has been seriously crippled by the loss of experienced surfmen, who are leaving the station crews in constantly increasing numbers for occupations where the work is less hazardous and the pay better. It has become necessary to fill their places with men who in many instances are inferor in capacity and character. That the morale of the station crews has been thus injuriously affected is forcibly shown by the growing number of dismissals for cause. It is confidently believed that some measure of the character referred to would provide an effective remedy for the conditions complained of, and attract to the service and permanently hold properly qualified men."

The Lake Shore & Michigan Southern Ry., has been engaged this year in building two additional tracks, to form a four-track road, on the Eastern division, between Buffalo and Cleveland. For several months past 28 work trains, seven steam shovels and large numbers of laborers have been engaged on this division. There is now completed and in operation 64 miles of four-track road and 52 miles of three-track line, between Buffalo and Cleveland. It is estimated that two more years will be required to complete the four-track line on the whole division. At Erie the company is constructing a freight house 500 ft. long.

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A TRIP TO THE IRON MINES.

The American Steel & Wire Co., The Rookery, Chicago, Ill., is issuing a little monthly magazine entitled "American Wire Rope News". The subject matter of the magazine is by no means confined to the uses of wire, though it is quite copious on that subject. Excellent illustrations are given of modern buildings, such as the Empire building, New York, and the First National Bank building, Chicago, which it is truthfully claimed would not be commercially practical without the elevator and the elevator, of course, would be impossible without wire. Therefore, wire rope is the leading element in the tall building. The following account of a trip to the Lake Superior iron mines written by Mr. A. W. Douglas, vice-president of the Simons Hardware Co., will be found of especial interest along the lakes.

Our party gathered on the deck of the steel ore steamer Princeton, Friday, Sept. 1, and looked forward to great things; but no prophet could have foretold the wonders that awaited them in the round trip from Chicago to Duluth and the inspection of the great iron mines of the Northwest, for all of which they were the invited guests of the American Steel & Wire Co. We were all tinctured with the hardware business, for that was how we all made our living. We stood on the bridge and in the captain's way, asking him many foolish questions as he slowly backed out of South Chicago Harbor. The Princeton is an immense steel boat, 475 ft. long and 40 ft. wide, but even then not the largest of the company's fleet of 113 great ore carrying vessels that ply continually between the iron mines at the head of Lake Superior, and the furnaces and mills at Chicago, Cleveland, Lorain and other ore unloading points. It was night as we passed out by the great steel mills that lit up the surrounding country and far out into the water, and in the red glare of which we rapidly slid along through the still, black water 'way down over the horizon line into the far beyond.

At midnight everything in the boat developed a tendency to stand on its head. The greatest storm in years rolled down the three hundred miles of Lake Michigan and struck us square in front, washing clear over the vessel. The waves hit the great steel hull so that it rang like an empty boiler under the Titan blows and made us think of being aboard Rojestvensky's flagship while Togo was paying his respects. We hardly slept, but in one fitful doze our host Mr. Baackes was heard to murmur "to hades with lake trips—me for the land." Genial Captain Chambers earned his pay that horrible night, for all through the storm until sunrise he hung to the rocking bridge and watched his vessel scrape the black sky on the ridges of the waves, and again sink into their depths like an elevator that had broken its rope. But storm or calm are all alike to him—he knows his magnificent boat and he knows his business and with such a man it is easy money to be rocked in the cradle of the deep.

The sun arose glorious the next day, with the peach-laden shores of Michigan on our right. And the next days were delightful beyond description as we sailed through the St. Mary's river and through the locks of the Sault Ste. Marie. We sailed in a great company of ships almost like a grand procession, for in front of us and behind us far as the eye could reach was the vast shipping of the lakes, many of the vessels belonging to the Corporation. It made it easy to comprehend that there were 113 great steamers like our own splendid vessel, all belonging to the Corporation and in constant service transporting 18 millions of tons of iron ore from the head of Lake Superior to its mills—which will constitute this year's tonnage of ore to be worked up into wire and other products of steel.

At the Soo locks we were joined Sunday by a remodelled ferry boat which made fast to our vessel and quickly sent over a gangplank our supplies—spiritual, mental and material but mostly material—to last until we should return. It was all done so quickly and everything was so complete that our admiration was excited; and as the little vessel departed we thought how well the small boy had named this little waterwaiter the "Steel Company's Grub Basket."

That Sunday night was the fiercest known on Lake Superior. It was destined that we should come in contact with the awful sorrow that visits those who go down in ships; and while we did not suffer, yet all about us felt the hand of Death. The great storm through which we sailed on Lake Michigan had ceased, to burst forth again in redoubled fury on terrible Lake Superior. Great steel vessels were compelled to turn tail and run to harbor with their holds filling with water. One great vessel sank on the rocks and broke in two—we saw her. Minor craft of all sorts found the sailor's grave. Forty-five people perished in the icy waves of Lake Superior that night. We passed through only the fringe of this holocaust. Capt. Chambers skirted along the northern shore, and while we rolled in troughs of the mighty seas we did not catch the full force. Lake Superior can almost equal the Atlantic in fierceness of storm and wave, and the hardy salt who faces undaunted the mighty billows of the ocean, recoils in terror from a Superior hurricane.

The northern end of our trip was reached and we slowly steamed into Two Harbors Monday night with the moon, the northern lights and the stars struggling to outshine each other while over all like a great eclipse loomed the huge ore docks and hoists of the Steel Corporation from which towering heights the ore is poured into the vessels.

Friends were awaiting us at the special train which carried us to Duluth, there to meet our hosts and some more hardware men from the Twin Cities and Duluth. A few hours were spent pleasantly at the Kitchigammi Club; then again to the special train, and we awoke the next morning at Ely. After breakfast, we descended into the great Pioneer Mine, one of the "deep" mines, in which the hard hematite ore is found. We all clung to each other on an elevator which dropped us down into the darkness and silently we wondered if we would ever see daylight again.

Most quickly and easily we were transported to the tenth level and there disembarked under the guidance of Mr. Olcott and the superintendent of the mines, Mr. Trenoza. We inspected the galleries where the ore was being dug, saw the intelligent manner in which the ore was quickly transported in electric trolley cars to the entrance and hoisted to the top. Everything seemed to work in clocklike fashion, and as we listened to the explanation of the superintendent we realized how skill, brains and money were handling this ore proposition in a way that was economical and efficient. One of the most curious experiences was to find at the extreme bottom of the mine a magnificent pumping engine completely installed and lifting the water in one stroke 1,000 feet to the top of the ground.

Of course, we were full of eager curiosity and asked a great many questions. This curiosity led some of our number into following the superintendent up 30 ft. on ladders, that led through narrow holes from one level to another. Mr. Baackes, with his usual aggressiveness, led the way, but he forgot that the holes were not made for a man who had acquired the rotundity of high living and an easy

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conscience; and when he got to the top of the first ladder, he stuck and could neither move forward nor backward. Those behind him on the ladder were trembling with apprehension lest he should suddenly conclude to drop down on them—specifications were rife as to whether they would ever have been able to separate one from another if such a terrible thing had occurred. Fortunately, with much effort he managed to get through, and just how much of his hair turned white during those few seconds he himself will have to tell. When the mine inspection was over we stood grouped outside one of the mines for our photograph.

A pleasant run on the two roads (for there are two of them, both the property of the Steel Corporation—the Duluth & Iron Range and the Duluth, Missabe & Northern) brought us to the Mountain Iron mine, known as the "open pit" variety. Standing on the bank over an immense excavation, we looked down into a hole something like 200 to 300 feet deep and nearly a mile in circumference; and at the bottom were innumerable lines of railroads, puffing engines with ore cars, and great steam shovels digging out ore as though it was so much sand or gravel. They dumped it into the cars, which were quickly hauled to the top of the pit. We were told that over 12 million tons of ore had been taken from this pit during the past 12 years, and the calculation is that over 3 million tons will be taken out this year. There is probably nothing so large in the world, and it is a curious experience to see the ore dug out with as little ceremony and apparently as economically as though it was so much clay. It seems that this is more particularly soft ore and runs something like 66 percent of pure iron.

It was a fascinating spectacle, and one we were loath to leave. The great ironmasters of Europe, who have come thousands of miles over land and sea to view this scene, have been struck dumb with astonishment and amazement that such things could be. They realized then for the first time the enormous strength of the Steel Corporation that owns these mines, steamboats, railroads, ore lands, coke lands and pretty much everything else in sight.

Nothing struck us more forcibly than the unity and harmony prevailing among the high grade, intelligent and efficient men with whom we were in contact, the interest which they display in their work, their discipline, their skill and the manner in which they all pull together. It is certainly a tribute to those at the head of this corporation that they have so many able lieutenants in their employ who have the spirit of co-operation among them. There was a feeling among these men—among the presidents of the railroads, the superintendents of the mines, the chemists in charge of the analysis of the ore, the superintendents of transportation and all the rest—that the corporation, financially and commercially, is founded upon a rock, and that it has, to a large extent, pre-empted the basis of success in the iron and steel trade—the command of raw material and transportation facilities.

Late that night saw us again at Two Harbors; we went aboard and watched with interest the loading of the ore. We had seen it mined; we had seen it dumped like so much red earth into special ore cars; had viewed the innumerable trains bearing it to Two Harbors; had watched the trains run on the immense ore docks and deposit the ore on the docks. Now we saw the ore poured into the hold of our vessel continuously and economically. Early Wednesday morning the loading was completed and we steamed out of Two Harbors and turned homeward.

Friday afternoon as we tied up to the docks in Chicago we saw the final story of the ore as it was being made into iron. Huge clam-shell shovels that lifted 10 tons each were quickly unloading the ore steamers. The ore was taken out and dumped into piles, and from there automatically carried to blast furnaces for the beginning of its conversion into iron.

BANQUET TO TOLEDO SHIP BUILDING CO.

The Chamber of Commerce of Toledo last week tendered a banquet to the officers of the Toledo Ship Building Co., and a number of speeches were made emphasizing the advantages of Toledo as an industrial center. Mr. R. A. Bartley, president of the Chamber, presided. The principal address of the evening was delivered by Mr. Charles B. Calder, general manager of the new Toledo Ship Building Co., who said:

"The welcome that has been extended to the new shipbuilding company by the city of Toledo, both through the press and by individual expression, has been so cordial and so sincere that it is impossible to find words to express our appreciation. Although less than two weeks have elapsed since we came among you, you have already made us feel at home.

"The city of Toledo was not a blind selection as the home of the new company. Its promoters were drawn to this city because of the unusual advantages it affords as a business center, and especially in the line of shipbuilding.

"The dock frontage affords ample room and is an excellent place for ships to winter and make the usual annual repairs. The location of the city on the through railway lines to all points of the compass, its proximity to coal fields and its freedom from labor troubles, all go to make this city an ideal commercial center, and all were considered before it was decided to locate the new enterprise here.

"The city is a natural terminal, both for receiving ore from the north for distribution and for receiving coal from the south to be shipped north and west; the wise shipbuilder locates his yard at such terminals.

"Cleveland, Lorain and all the ports on the south shore of Lake Erie are already overcrowded. Toledo is a natural place for ore and coal to meet.

"Everyone connected with the company has the utmost faith in the future of the city. Its reputation for push and business energy is recognized throughout the country, and the new company steps in its place among the permanent institutions of the city to do what it can for its future.

"It goes without saying that we are going to more than double the capacity of the present plant. Plans are being prepared now for the second and third drydock, so that we can commence operations on these as soon as spring opens.

"It is no small advantage to the new company to take over a plant of the character of that of the Craig Shipbuilding Co. They have done the pioneering in the steel shipbuilding of this city, and they may have built better than they know. If the new company puts the same energy in the enterprise that the former owners have in the pioneering under discouraging surroundings, I would not dare to predict what the future will bring.

"I have known Mr. Craig personally since 1881, and he has been a friend to me always pleasing to meet. He and his sons have overcome obstacles by sheer force of energy. If we do all that the newspapers say we are going to do, we will have no time for framing speeches, but actions speak louder than words, anyhow.

Mr. Calder was followed by Mr. Howard I. Shepherd, cashier; John Craig, Merwin Jackson, Frank L. Mulholland and Mr. Charles W. Burrows.

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Published every Thursday by

The Penton Publishing Company

CLEVELAND.

CHICAGO: MONADNOCK BUILDING.
PITTSBURG: PARK BUILDING.
NEW YORK: 150 NASSAU STREET.

Correspondence on Marine Engineering, Shipbuilding and Shipping Subjects Solicited.

Subscription, $3.00 per annum. To Foreign Countries, $4.50.
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The Cleveland News Co. will supply the trade with the MARINE REVIEW through the regular channels of the American News Co.

European Agents, The International News Company, Breams Building, Chancery Lane, London, E. C. England.

Entered at the Post Office at Cleveland, Ohio, as Second Class Matter.

DECEMBER 21, 1905.

PRINTED IN AN OPEN SHOP

There are only three changes of any importance in the shipping bill of the Merchant Marine Commission from the form in which the bill was originally introduced. When congress, by Act of April 15, 1904, fixed July 1, 1906, as the date on and after which the carrying trade between the Philippines and the United States should be reserved to American vessels, it was believed that the tariff reduction on Philippine products sought by the administration would very soon become effective. But the reduction desired by the president and Secretary Taft has not yet been made by congress, and economic conditions in the Philippines continue to be rather depressed and discouraging. Because of this fact, because of the doubtful meaning of certain phrases in the Paris peace treaty, under which Spain might claim the coastwise privilege for her own vessels, both the president and Secretary Taft have recommended that the application of the coastwise principle to our Philippine commerce be postponed until 1909, when the treaty terms as to Spanish ships and goods will expire.

The postponement desired by the administration has been granted by an amendment made by the commission to section 2 of the bill, which provides, as a substitute for the coastwise privilege, an especial subvention of 30 percent above the general rate of $5 per gross ton to cargo vessels, or $6.50 per ton per year, to all American vessels engaged in our commerce with the Philippines.

It is the belief of the majority of the commission that the application of the coastwise principle to our Philippine trade on July 1, 1906, would not lead to any such great increase in rates as has been predicted by opponents of the measure. But some increase, even though a relatively small one, would be inevitable, and there would be, further, some temporary inconvenience attendant on the change from the old policy to a new one. If the Philippines were highly prosperous, an increased freight rate could be borne without much difficulty. But unfortunately the islands are not prosperous, and not able to endure, just now, even a small increase in the cost of conducting their trade with the United States. These are the chief considerations which have led the Merchant Marine Commission to make the amendment postponing the coastwise legislation until 1909.

It has been asserted that this coastwise legislation would both increase freight rates and reduce facilities. But no such objection can be urged to the new plan proposed by the Commission of keeping the Philippine trade open to foreign vessels but providing a special inducement for American vessels to enter it. The result of competition between the foreign vessels now engaged in the trade, and American vessels aided by the special subvention of $6.50 per ton, will manifestly be an improvement in both rates and facilities. Secretary Taft and Col. Edwards, chief of the bureau of insular affairs, who were averse to the coastwise legislation, are earnestly supporting this new proposition of the shipping bill, as beneficial both to American shipping, and to interests of the Philippine archipelago. The principal shipowners who have contemplated entering the Philippine trade, regard the change as an inevitable one, and are not dissatisfied with the amendment to the shipping bill. But they believe that this amendment makes it all the more necessary that the bill should be enacted at the present session of congress.

The second of the three amendments to the shipping bill increases by $250,000 the present maximum subvention of $757,000 a year, payable under the Postal Aid Act of 1891, to the American Line of trans-Atlantic steamers, from New York to Cherbourg and Southampton. Vice President Franklin of the International Mercantile Marine Co., which owns these steamers, has recently renewed his mail contract with the post office department. But it was urged with great force before the commission that

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the new British subvention of $1,100,000 to the Cunard company would mean intensified competition for the American Line, which, it is said, has never made any dividends out of its fast and expensive steamers. The American Line is the only trans-Atlantic company which is required to maintain a 20 knot service all the year round. The two German companies have a few steamers that are faster, but as a rule these "greyhounds" are not kept constantly at work. Moreover, the United States gives mail pay freely to these foreign steamers, to the extent of several hundred thousand dollars a year, while the rigid protectionist policy of the British government, reserving the west bound mails to British steamers, deprives the American Line almost wholly of income from this source. The proposed addition brings the American Line compensation up to the original figure of the law of 1891, which was cut down when passed by the house of representatives.

The third amendment to the bill adds $217,000 to the present compensation ($283,000) of the Oceanic Steamship Co., for its swift mail service from San Francisco to New Zealand and Australia. This service is now being performed under the postal aid law of 1891. The Oceanic steamers run at an average speed of 15 knots for 8,239 statute miles, which is said to be the fastest service in the world under like conditions of climate and distance. This company employs white crews only instead of the Asiatics often utilized in the Pacific. Its present rate of subvention is far lower than that of the European and Asiatic lines entering Australian waters. The company has lost money steadily under this contract, but American exports to Australia, with the assistance of such a swift and regular mail service, have increased from $12,000,000 in 1896 to $27,000,000 in 1904. The Oceanic Line gives the United States regular and direct connection with our naval station at Samoa. It has been announced authoritatively that unless the subvention for this Austrialian service were increased, the ships would be taken off and the line abandoned. In that case the large trade built up by these American steamers would go to other countries, and especially to British Columbia—a competing line of subsidized British steamers running from Vancouver to Brisbane.

FREIGHT RATES DURING 1906.

Carrying charges on ore during 1906 will be the same as they were during 1905, that is, 75 cents from the head of the lakes, 70 cents from Marquette and 60 cents from Escanaba. Vessel owners are hoping for a somewhat better rate but when the shippers came into the market to charter tonnage there was no difficulty whatever in obtaining it. Independent interests have chartered vessels to move about 9,000,000 tons, and while the Steel Corporation has not as yet parceled out its ore requirements, it will probably charter about 8,000,000 tons. It moved during the season of 1905 over 18,000,000 tons of ore and will probably move a greater amount during 1906. Roughly speaking, the Steel Corporation's vessel capacity will be about 11,000,000 tons next year. Out of the total of 33,500,000 tons of ore moved on the lakes during the last year, only 3,500,000 tons of it was moved by wild vessels, proving the absolute dominion of the contract system in the movement of this commodity. Probably by the first of the year vessel owners will have all their work outlined for the season of 1906. The iron mining companies will by that time have sold all the ore they care to promise to deliver during the season.

STEEL FREIGHTER FRANK C. BALL.

The launch of the steel freighter Frank C. Ball at the yard of the Great Lakes Engineering Works was a great success in every way, the steamer taking the water on a perfect line and exactly on the minute of two o'clock, the time set. A brief description of this steamer was published in the last issue of the *Review*, but it might be well to call attention to a new departure in this steamer, that is, the self-stowing anchor hawse pipes or what may be termed more properly hawse boxes. The anchor will have its flukes stowed inside the ship, leaving nothing outside the hull except the flange or base of the fluke which will close the opening in the hawse box, thus leaving the outside of the hull practically without dangerous obstructions and consequently reducing the danger in case of collision due to projecting anchors. The boilers and engines are rapidly being installed in the new steamer which will have the same size boilers as have been put in the large steamers building for the Pittsburg Steamship Co., such as the Corey. It has been thought advisable to give the Ball ample steaming capacity.

MR. FRANK C. BALL, MR. JAMES E. DAVIDSON AND MISS ELIZABETH PESSANO, SPONSOR.

M. A. Hanna & Co. announce that the two boats building by the American Shipbuilding Co., for the Cambria Steel Co., will be duplicates of the 600-footers ordered for the Pittsburg Steamship Co. They will, therefore, be 600 ft. over all, 580 ft. keel, 58 ft. beam and 32 ft. deep. The engines will be triple expansion with cylinders 24, 39, and 65 in. diameters by 42 in. stroke, supplied with steam from two Scotch boilers, 15 ft. 4½ in. diameter by 11 ft. 6. long.

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Marine Steam Turbine Development and Design.*

BY E. M. SPEAKMAN, ESQ., ASSOCIATE MEMBER.

Few who saw the tiny experimental launch Turbinia steaming between the lines of warships at the Spithead naval review in 1897 would have prophesied that, in less than eight years, the steam turbine, then regarded with distrust even for electrical work, would have been so far developed as to have been applied to the largest and fastest ocean-going steamers ever built, and have begotten sufficient confidence in its characteristics to justify its wholesale adoption in the warships of the largest navy in the world.

First commercially adopted in the King Edward in July, 1901, there is now (September, 1905) about 700,000 I. H. P. of marine turbine machinery built, or under construction, among which are the largest marine installations ever contemplated, the fastest mail steamers of all sizes ever built, and by far the fastest torpedo craft, while in many installations records have been made for economy of consumption, or saving of weight of engines.

The adoption of this type of motor—the Parsons type is referred to unless otherwise mentioned—has had a very marked and extremely valuable effect in shipbuilding circles, by causing a far more critical and retrospective view to be taken of ordinary machinery, and also, what is yet more important, necessitating closer attention to the question of propulsive efficiency.

The rapid development of the marine turbine has taken place entirely in Great Britain; a few experimental vessels have been built here and in Europe, but nothing has yet been done commercially. Now that the proportions of turbines and propellers can be determined with ample accuracy to enable very stiff guarantees to be made, both for speed and economy, a similar development may be expected in other countries.

In table A is given a complete list of turbine steamers and their leading dimensions, a course that seems preferable to giving individual facts in the following section.

PART I. DEVELOPMENT.

Compound steam turbines, on Mr. Parson's well-known principles, had been made in small units since 1885, but it was not till 1894 that any definite attempt was made to apply them to ship propulsion.

Originally fitted with one radial turbine and one shaft, the Turbinia had a checkered experimental career before finally attaining, in 1897, a speed of about 33 knots, the ratio of $\frac{I}{\sqrt{L}} = 3.3$ being quite abnormal. Public attention was first directed to this famous little vessel at the naval review, in that year, and soon after (in July, 1897), the British Admiralty was approached with the idea of getting turbine machinery fitted to a destroyer. The result was the order for the Viper early in 1898, the vessel being launched in September, 1899. Of the same size as the numerous 30 knotters then under construction, but of double the power, and being only the second vessel fitted with turbines, the Viper was, in many ways, one of the most remarkable examples of naval architecture and marine engineering ever built. Strictly speaking, the Armstrong Co. had placed the order for the Cobra's turbines before the Viper was officially ordered, and with the former were carried out the greater share of the preliminary trials. Run into and much damaged while lying at her pier on the Tyne, the Cobra's completion was delayed, and her official trials, after being bought by the Admiralty in May, 1900, were not carried out till after those of the Viper. The turbines in both boats were exactly the same, and practically similar to those of the Velox. No provision of any sort was made for cruising purposes in the way of adding supplementary turbines such as are now fitted, and the consumption of the Viper was excessive at low speeds. When, however, the proportion of power at which her turbines were then working is considered the amount is not surprising, and improved results were obtained in the Cobra by using only the port engines on the low speed trial and allowing the starboard ones to run idle. The Cobra was tried at about 440 tons displacement and the Viper at about 380; the results obtained being somewhat as follows:

Viper.	Speed	Equivalent I. H. P.	Mean R. P.M	Total coal burnt lbs. per hour	Coal per I. H. P. per hr. lbs.
Full power, 13 7-1900, 1 hr.	37.113 / 36.585 Max.	13,000	1,180	34,500	2.61
3 hours F. P. C. C. 31-8-00	33.83	10,300	1,050	25,700	2.49
3 hours, official trial	31.118	8,350	950	19,800	2.38
12 hours, slow speed trial	15.	750	450	3,000	4.03
Cobra.					
Port engine only	15.0	850	550	2,750	3.23

The end of both vessels was disastrous. The Viper after being in commission some time was sent out for the naval manoeuvres in 1901, and while scouting at high speed in a fog ran ashore and became a total wreck. The Cobra leaving the Tyne to go around to Chatham, broke her back in a heavy sea and sank. The loss of these vessels, and, with the latter, of several of the chief members of the staff of the Parson's Marine Co., considerably delayed the proposed comparative trials with other destroyers. By this time, however, the first commercial turbine steamer, the King Edward, was in service. Laid down late in 1900, the trials were run in June, 1901, and the vessel put in service on July 1, that year. Her performance was watched with intense interest and to the excellence of the results obtained with her and the Queen Alexandra, which followed during 1902, may be assigned the revolution in cross-channel boat machinery that has taken place in the last four years. Similar in general style, both vessels are remarkable for their light draught considering the power and the speed; distinct minor improvements were made in the latter vessel, which, when out of commission between seasons, has been largely used for experimental work.

After the trials of the Viper another destroyer, H. M. S. Velox, of similar size was laid down, being launched in February, 1902, and in this vessel an effort was made to obviate the excessive consumption at low speeds by fitting two small reciprocating engines to the inner shafts. These small triple expansion engines were not reversible and added slightly to the weight, though they materially improved the economy up to 12 knots, above which they are disconnected. This is the only attempt hitherto made by Mr. Parsons to fit a twin system, though a similar arrangement in the Caroline, built by Messrs. Yarrow, was tried in conjunction with Rateau turbines.

Meanwhile the Admiralty, being naturally impressed with the success attending the King Edward and Queen Alexandra ordered two third-class cruisers—the Amethyst and Topaze—the former being fitted with turbines and laid down in January, 1903, the latter being fitted with the most modern type of reciprocating engines. The experiments to be carried out with these vessels were awaited with considerable interest. A 550-ton destroyer, similar to those of the new type laid down about 1902, was also ordered with turbine machinery, and several commercial vessels were commenced as soon as the performance of the Queen Alexandra had

*Paper read before the Society of Naval Architects and Marine Engineers. For the fine discussion on this paper see *Marine Review*, Dec. 7.

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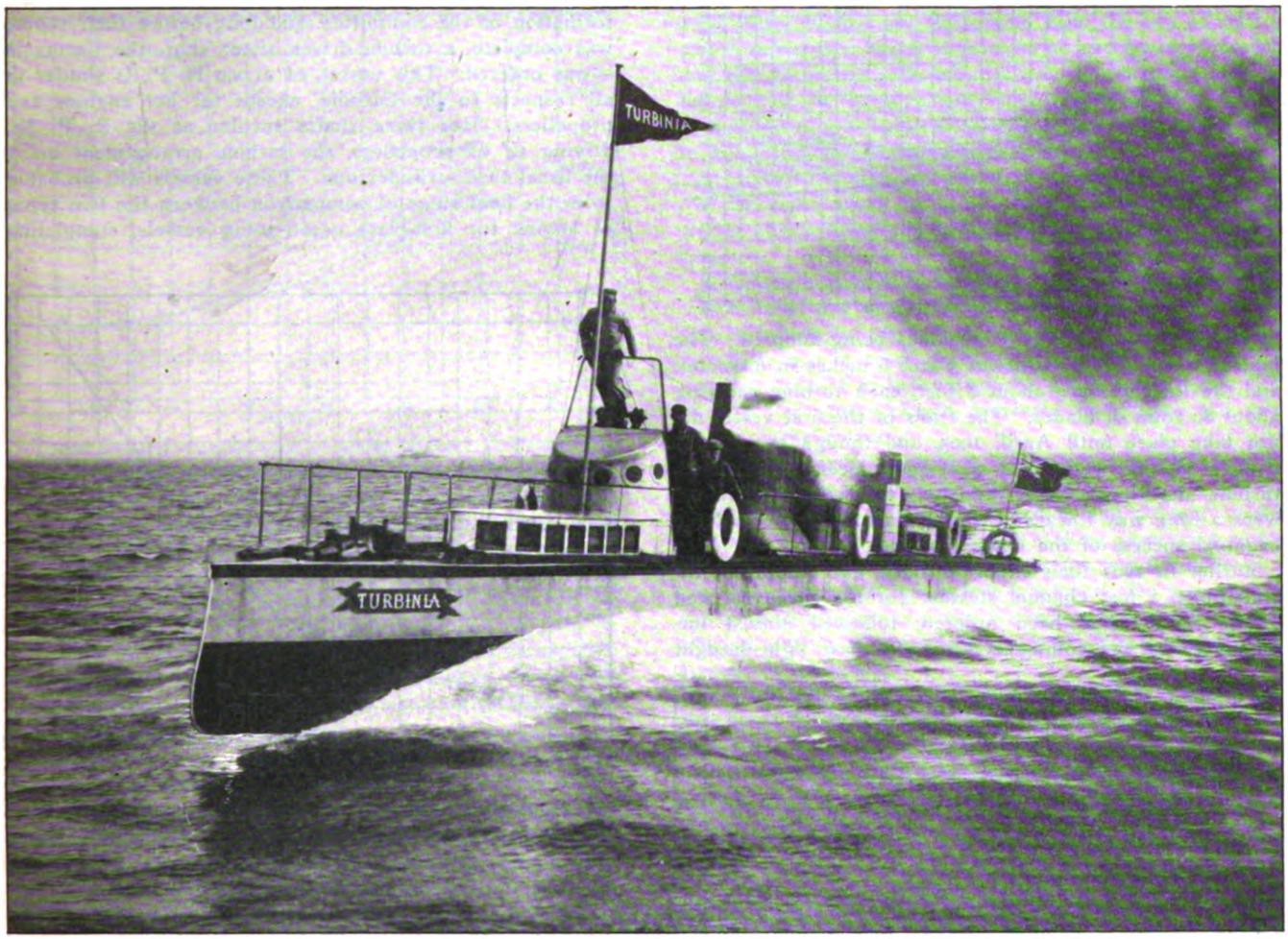
shown results similar to those of the King Edward. The progress of the marine turbine, up till June, 1903, is fully dealt with in Mr. Parsons' paper to the Institution of Naval Architects.

The development since then has been very rapid. In 1903, the Emerald, Tarantula, and Lorena were completed and also the channel steamers Queen and Brighton. Commercial experience with the latter two vessels has induced the owners of the Queen to order two more similar vessels, the Onward and the Invicta, while for the New Haven and Dieppe service, the Dieppe is practically a duplicate of the Brighton. The Tarantula and Lorena have been the subject of an official report by officers of the navy department, while the Emerald is noteworthy in that on her were carried out the experiments dealing with the number of screws per shaft, results being obtained which were afterward confirmed by experience in Turbinia, Queen Alexandra and Queen.

These experiments were of considerable importance, and resulted in a change of ideas regarding turbine driven propellers. The Emerald was fitted with the usual arrangement of three shafts, the H. P. turbine driving the center one which carried a single propeller, and exhausting into a low pressure turbine on each side, which drove the wing shafts. (Some economy of weight results from using a 3-stage turbine with an H. P. and M. P. cylinder driving the two outside shafts, and the L. P. one the center, compared with this arrangement of one H. P. and two L. P.'s; but the power of manœuvring ahead and astern on each side is not readily obtainable.) In the King Edward, Queen Alexandra, and Queen, and, to begin with the Emerald the wing shafts carried two screws on each, separated by about 2½ to 3 diameters. Considerable vibration occurred, due to the proximity of the forward screws to the hull, and as the suppression of these without other alterations led to no change in speed, a series of trials was made which determined the superior efficiency of single propellers. The improvement in over all efficiency which result has been continued by the adoption in other types of vessel of larger propellers and slower speeds of rotation, and further experience has shown the advisability of running at about the same revolutions with each shaft. The reason of this increase in propulsive efficiency is that the propeller efficiency improves far more rapidly with increase of size than the turbine loses; in fact, the economy of the latter remains constant over a very wide range of speed if designed for the same internal conditions.



TURBINIA, THE FIRST TURBINE STEAMER.

The trials of the Queen in June, 1903, were attended by numerous eminent naval architects, of whom Prof. Biles and his partner had under consideration at that time, the designs for four channel steamers for the Midland Railway Company. Reference is made to them in Section II. It is sufficient to remark here that of these vessels, two were built and engined by Messrs. John Brown and Messrs. Caird with the ordinary type of engine and an abnormally high efficiency obtained from them. The other vessels were engined by Messrs. Parsons, and all four were minutely described in *Engineering*, October, 1904, and in Mr. Gray's paper to the Institution of Naval Architects in 1905. The comparative trials of these vessels, representing the most modern practice in channel steamers formed an important step in the acquisition of data as to the relative efficiency of the two systems.

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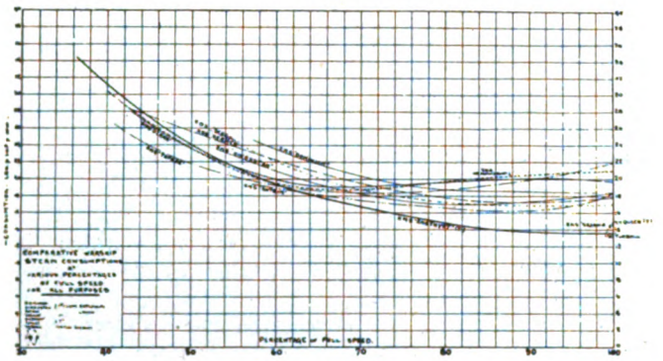
The next step was the adoption of turbine machinery in two large steamers for the Allan Steamship Company. These vessels built for the Liverpool and Montreal traffic, were the first large ocean-going vessels fitted with turbines. Built for a sea speed of 17 knots, they attained about 19½ on trial, on a slightly reduced draft, the turbines running at about 275 R. P. M. The second vessel of the pair, the Virginia, has been remarkably successful, breaking the Canadian record on several occasions. The vessels are fitted with 3 shafts, the usual arrangement

Fig A.



of the H. P. and two L. P. turbines being adopted. The high-pressure turbine is about 5 feet 6 inches in diameter, and the low pressure about 8 feet, each turbine carrying about 80 rows of blades. The trials of the first vessel did not take place until April, 1905, and though the largest vessels in the world had previously been commenced, turbine machinery being adopted, the results obtained went a long way towards assuring naval architects of the eventual success of the Cunard vessels.

Earlier in 1903 than either of these two important installations, a fast channel steamer for the Stranvast and Larne service had been ordered, followed almost immediately by the commencement of a fast light-draught

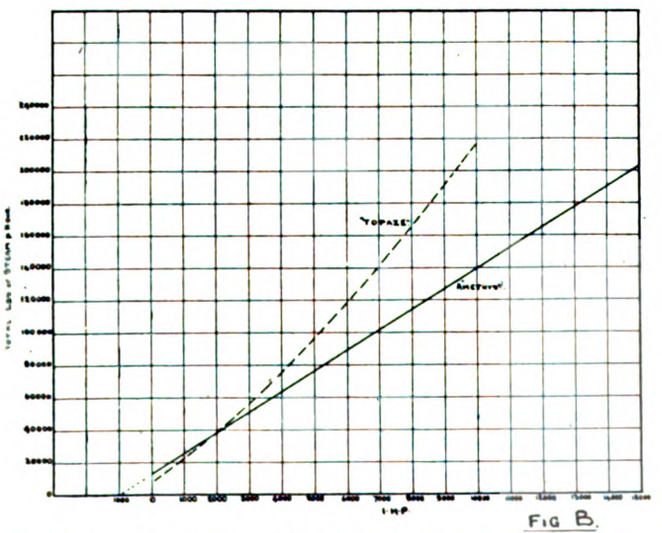


Fig B.

vessel for the Union S. S. Co., of New Zealand. This latter vessel, the Loongana, left the Clyde in August, 1904, and ran to Port Said without a stop—3,350 miles at 16 knots—completing her voyage to Melbourne, Australia, from Glasgow, in 30 steaming days. The average speed over the whole distance was about 16.5 knots, at which the coal consumption was about 1.6 pounds per I. H. P. per hour, the full speed being over 20 knots.

The most important feature in the development of marine turbines has, undoubtedly, been the decision of the Cunard S. S. Co., to adopt turbines for the new vessels of that line. For some time it had been evident that new mail steamers would be required, though for many reasons the date of ordering them was postponed again and again. In September, 1903, however, the Cunard Company appointed a commission which consisted of seven gentlemen of very high standing in the profession, including representatives of the Admiralty, the Board of Trade, and of the manufacturing companies concerned, to investigate this question of design, and especially the type of engine to be adopted. At this time, the Caronia was being built by Messrs. John Brown for the Cunard Company. She is fitted with quadruple expansion reciprocating engines driving twin screws, and soon after the formation of the committee, and long before their report was complete, a turbine-driven sister ship—the Carmania—was ordered. This vessel, of 21,000 H. P., is similar in all respects to the Caronia, except for her engines and propellers. Her three shafts revolve at 185 R. P. M., driving 14′ 0″ propellers, the turbine arrangement being the usual three-cylinder one. These vessels will probably form the final stage of comparison between the two types of engine for first-class ocean-going vessels, completing

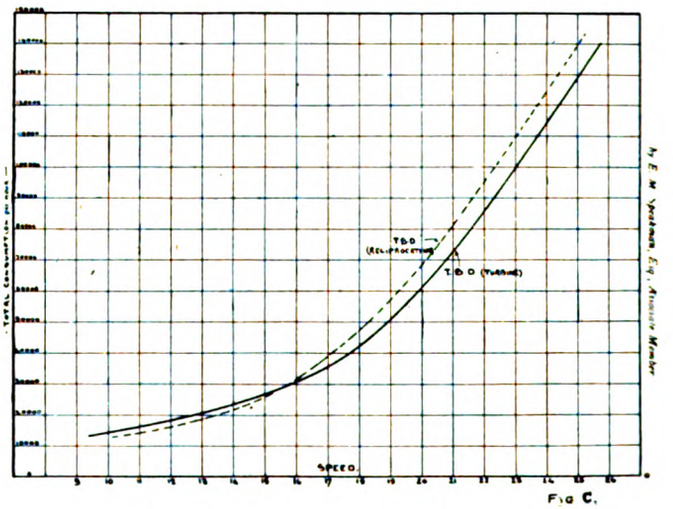


Fig C.

the invaluable series of comparative trials that have been carried out in various types of vessels—destroyers, cruisers, channel steamers, intermediate steamers, and, finally, in these Cunard vessels, of first-class mail boats.

The Cunard Commission report has been treated as confidential, and rightly so. Their investigations were most thorough and embraced very careful trials and experiments, not only on ships and models, but on details of construction, and it would be hard to exaggerate the thoroughness with which these vessels—the largest in the world—have been designed. The tremendous increase in power necessary over anything that had been previously attempted, involved very great difficulties in the design of reciprocating engines. Twin screws were practically impossible, the dimensions of cylinders and shafting being prohibitive, triple screws necessitated a very awkward arrangement combined with many (and usually uncriticised) experimental features. Having regard to the design of turbines and the question of propeller efficiency a four-shaft arrangement offered the best solution in this particular case.

Considerable criticism has been levelled at this decision, and the subsequent wholesale adoption of turbines in the Royal Navy; but it must be remembered that the gentlemen responsible for it in each case were those who had complete access to all the data available on the whole subject, and that it was no case of competition, but the result of an earn-

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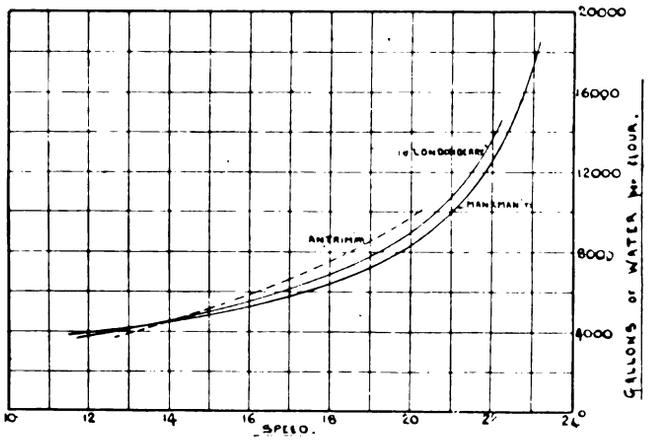
est and deliberate investigation, in both cases by the men most experienced in both types of engine, to decide which one was best suited to their own requirements.

Among the investigations that were carried out for determining the relative efficiency of the two systems, were trials made on the turbine steamer Queen, and the other vessels running on the Dover-Calais service, and also on the Brighton and Arundel on the New Haven and Dieppe station. These tests were amplified by data obtained from the Clyde turbine steamers and from two large destroyers tested by the Admiralty.

FIG. D.



These Cunard installations, of about 68,000 I. H. P. each are divided into two complete engines, of which the high-pressure turbine of each set drives the other shaft, while the low-pressure, with which is incorporated the astern turbine, drives the inner shaft on each side of the vessel. The high-pressure turbine drum is about 9 feet in diameter, carrying about 150 rows of blades, while the rather larger L. P. drum carries about half that number. The distorting effect of heat on the shape of cylinders of such immense size has necessitated very special design, but the care and skill with which the engineers responsible for the manufacture have proceeded, can only result in well-deserved success.

During 1904, early in which the decision to adopt turbine machinery in these vessels was announced, several orders were placed for vessels with turbines for all types of fast steamers, while the publication of the comparative results obtained from the Amethyst and Topaze was second in interest only to the Cunard installation.

In 1905, the Allan turbine steamers were tried, the new vessels for the Dover-Calais and Dieppe service commenced running, and the S. S. Viking, a pleasure steamer of 23.5 knots trial speed put in service, while three vessels of 23 knots and of 9,000-10,000 H. P. each, were ordered by the Great Western Railway company, and during the latter half of the year the orders for turbine machinery have been very numerous.

Another important decision, and one largely influenced by the report of the Cunard Commission and the splendid performance of the Amethyst, was that of the British Admiralty to adopt turbine machinery for its vessels. Triple shafts are adapted for the 26 and 33-knot destroyers, while a quadruple-shaft arrangement is to be fitted in the battleships and large cruisers.

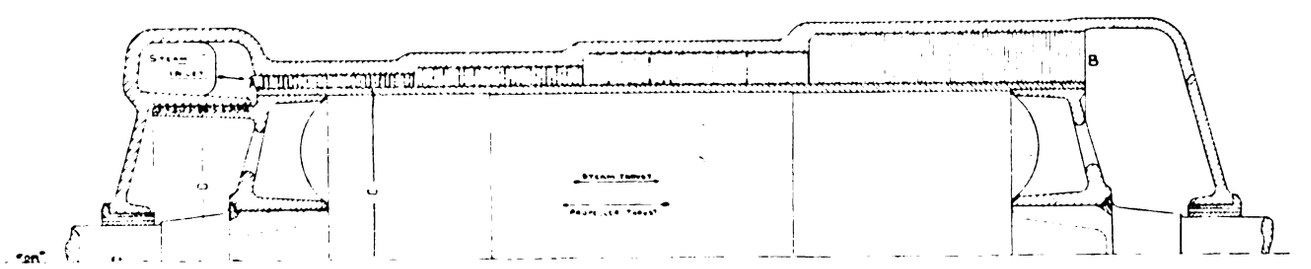
It will possibly be of interest to analyze the reasons for this rapid adoption of the steam turbine; the keen competition in Great Britain may have influenced it slightly, but for any motor to start commercially in July, 1901, and in March, 1904, to be adopted for vessels such as the new Cunarders, is prima facie evidence of some striking inherent excellence.

II. TURBINES COMPARED WITH RECIPROCATING ENGINES.

While many of the advantages claimed for the turbine over piston engines are inseparable from the use of such a motor, others are largely dependent on excellence of design, and the prescience with which these claims were made in the days of the Turbinia and Viper, has been fully justified in the light of later experience. These features are discussed in detail, and may be summarized as follows:

1. Increased economy in steam consumption.
2. Increased speed owing to considerable reduction in weight of machinery and smaller steam (and coal) consumption.
3. Complete absence of vibration from main engines.
4. Reduced cost of attendance and overhauling.
5. Reduction in oil and stores used.
6. Reduction in space occupied, if desirable.
7. Reduction of propeller diameter, which permits—
   1. For same draught, increased immersion, and prevents racing.
   2. For same immersion, a considerable reduction in draught.
8. Lower center of weight of engines and reduced weight necessary. There are, however, two striking advantages which are seldom or never quoted for the turbine, and these are—
9. The adaptability of turbine machinery for powers and speeds at which piston engines become constructionally impossible on account of weight, or of inertia stresses, and also on account of cavitation.
10. The property of maintaining the original economy on account of the absence of rubbing surfaces on which economy depends.

The difficulties originally found in applying turbines to marine propulsion were chiefly in the design, and are now largely overcome.



SECTIONAL ELEVATION OF H.P. CYLINDER OF A PARSONS TYPE OF MARINE TURBINE

They are:

1. The arrangement and design of propellers for high speeds of rotation.
2. The inefficiency of turbines at low speeds.
3. Reversing and manoeuvering qualities.

I. Economy. Due to the adoption of turbines in place of piston engines in ships of similar design, far more attention has been directed in the last three years towards the actual economy of the main engines as opposed to that of the complete installation, and the numerous trials made for obtaining the actual steam consumption show that, under the same conditions, reciprocating engines, of equally careful design

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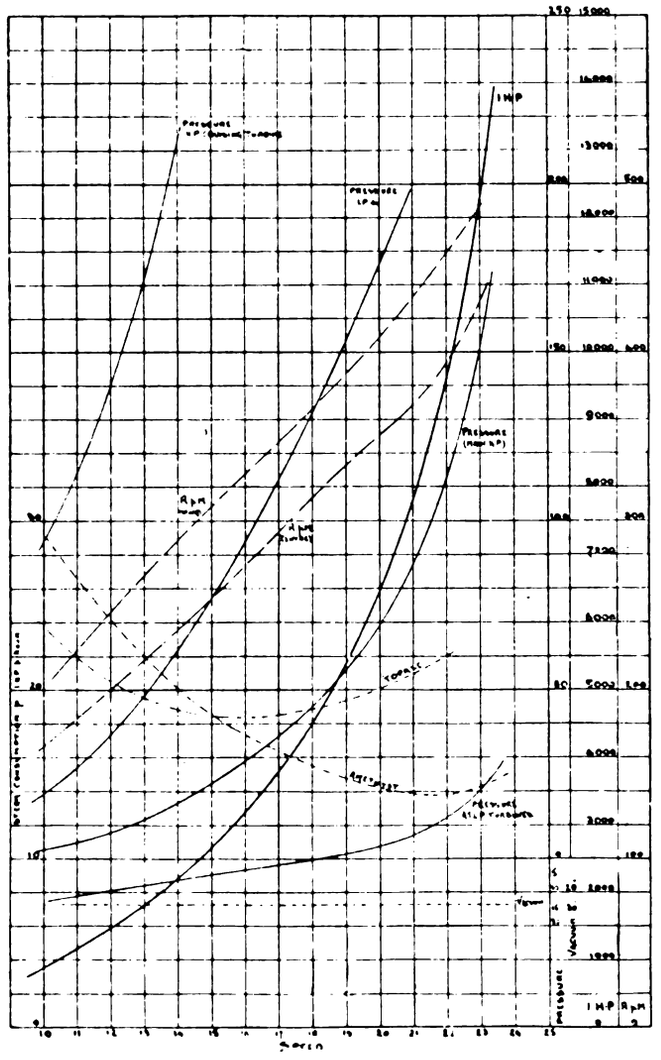
are only slightly more economical than turbines when working below about 60 percent of the vessel's full speed (that is, say 12 knots for a 20-knot ship), while above this the turbine is superior. Ample and reliable steam consumption data for all classes of warships is now available from trials conducted by the British Admiralty, who have also carried out careful comparative tests on cruisers and torpedo boat destroyers, exactly similar but for their propelling machinery, for the purpose of determining the relative efficiency of the two systems. Similar experiments have been carried out with channel steamers in a very comprehensive way, and in all cases the actual trials of the ships have been supplemented by elaborate tank experiments. The result of these investigations has been the adoption of the Parsons steam turbine for all classes of British warships.

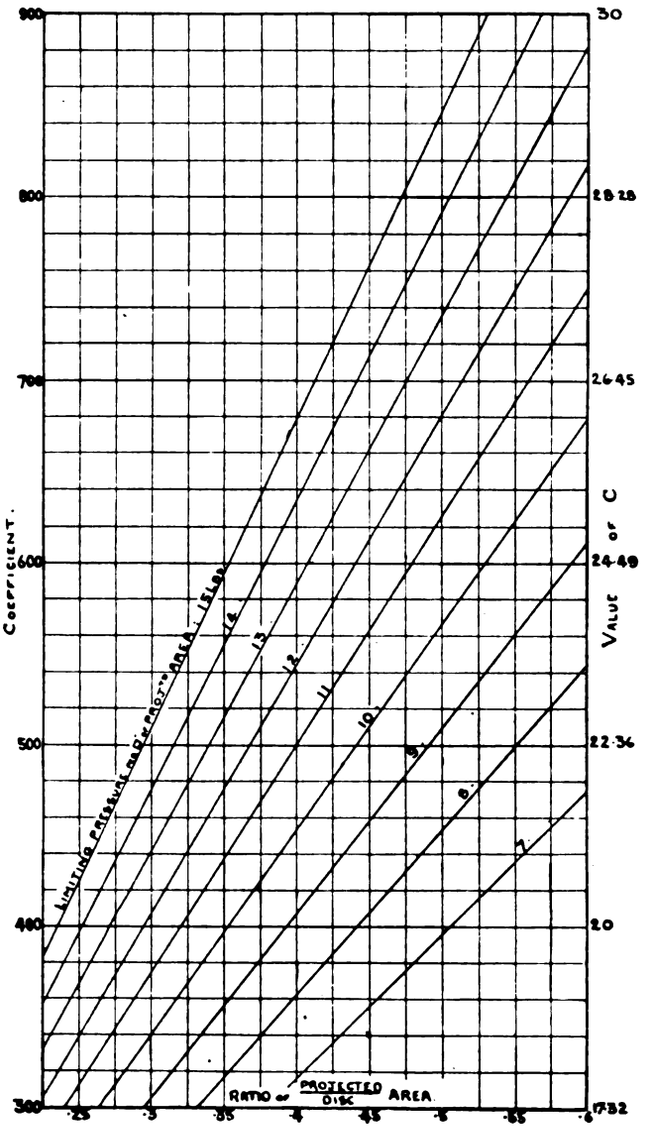


The cruisers tested were the Topaze and Amethyst, of 3,000 tons. Fitted with turbines, the Amethyst obtained a maximum speed of 1.5 knots more than the Topaze; for the same steam consumption, the speed of the Topaze was 21 knots against the Amethyst's 23, or for 22 knots the consumption per unit of power in the Amethyst was 13.8, and in the Topaze, 22 pounds. The progressive trial results are shown in Plate II.

Carried out with great care, and corroborated by the similar results obtained from the two sister ships of the Topaze, these long-desired experiments on similar ships, running under similar conditions, did more than demonstrate the superior economy of the turbine at full power. They showed that down to 14 knots the turbine was more economical, and that below this speed the difference in favor of the reciprocating engine was by no means as large as had been supposed. In fact, with the auxiliary exhaust steam being passed through the turbines, the economy is better above 10 knots.

Similar results were obtained from the trials of the Midland Railway steamers, which unlike the Amethyst were not fitted with cruising turbines. The greater economy of the turbine vessels was very marked at high speeds, and only ceased below 14 knots.

The question of economy is very important. It is, probably, the crucial point in considering the adoption of turbines, and even if the machine possessed no other advantages, economical results such as have been obtained



undoubtedly entitle it to careful consideration. On Plate III, in Fig. A, is given the steam consumption per I. H. P. of H. M. S. Amethyst, compared with that of other warships over a wide range of speed. Actual steam consumptions of merchant vessels run at low powers are almost impossible to obtain, but seeing that naval engines are designed to be most economical at about 80 percent of full speed, and that at 50 percent there is such a marked rise in their consumption, there can be little doubt that the performance of merchant engines, designed for maximum economy at full power, would be much the same at low speeds as that of the warships. There has been a tendency, due possibly to lack of data, to imagine that the consumption of ordinary engines at low speeds was not so great as recent trials have shown it to be.

Figure B gives the total consumption of the Amethyst and Topaze plotted on horse-power, while Fig. C gives a similar diagram for two destroyers tried. Fig. D gives the total

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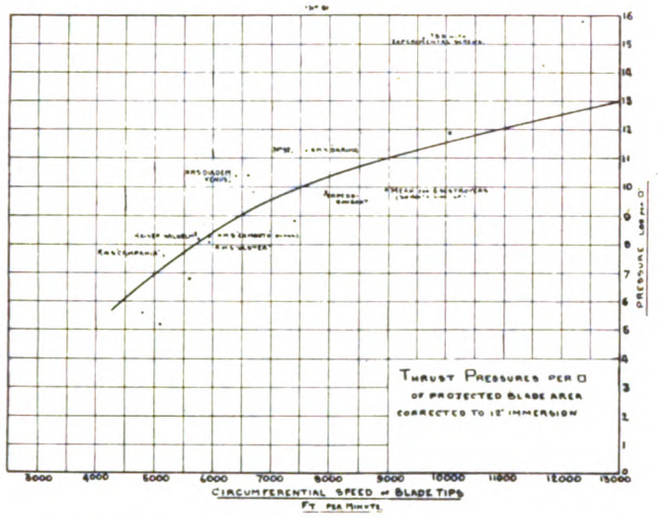
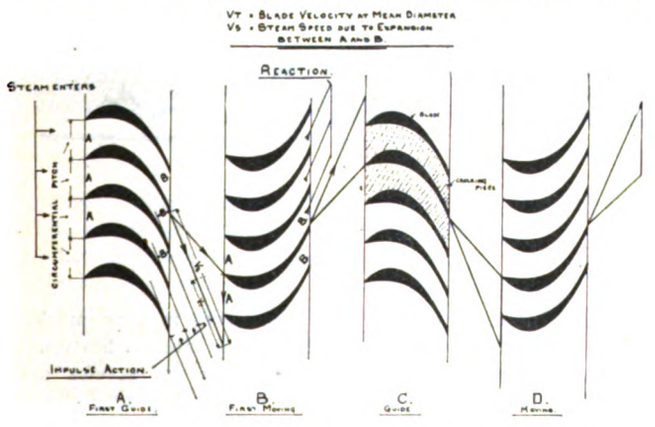
amount of water used at various speeds for the Midland Railway steamers. Similar results to these were obtained with the Brighton (turbine) when run against the sister ship Arundel, the efficiency increasing from about 6 percent at 16 knots to 12 percent at full speed. I do not think I can say anything to add to the convincing nature of these diagrams.

In considering the relative economy at low speeds, it is well to remember what these speeds actually are. The standard low power trials in the English navy are run at one-fifth of full power, which corresponds to 60 percent of full


THRUST PRESSURES PER □ OF PROJECTED BLADE AREA CORRECTED TO 18" IMMERSION
PRESSURE LBS. PER □"
CIRCUMFERENTIAL SPEED OF BLADE TIPS FT. PER MINUTE

speed, and only very rarely in large vessels are they extended below this. Torpedo craft are tried between 45 to 50 percent of full speed; their normal service cruising speed is between 14 and 15 knots. For long voyages, about 55 to 65 percent is a fair average, and at such speeds there is little difference in consumption between the two types of engine. As an instance of typical cruising speeds, the Japanese battleships steamed out from England to Japan at an average of 54 percent of full speed; while the Oregon's famous trip was made at about 66 percent. H. M. S. Terrible's recent voyages to China and back from Portsmouth were made at 57 percent, and the British battleships which



THE ACTION OF STEAM IN PARSONS BLADING.

recently returned from China made the trip at about 65 percent of full speed. The speeds kept up in the Atlantic manoeuvres of the British fleet in 1903 were very high—being at over 80 percent for several days, but on the other hand, the speeds used when blockading, as for instance outside Port Arthur, are necessarily very low. Many similar examples can be given, and if more data is required, the consumptions in Fig. A can be plotted on percentage I. H. P. instead of speed, when it will be seen that the superiority of the turbine disappears only below about 15 percent of the maximum I. H. P.

II. The reduction in weight of machinery is a feature of turbine installations closely allied with that of constructional possibilities. As for instance, in the Turbinia where the weight of turbines and shafting was 3.65 tons, or only 4.08 pounds per I. H. P. Of similar power, but for a lower speed, the Rateau turbines of the Caroline weighed 8.6 pounds per I. H. P.

In the King Edward, the weight of engines and condensers, shafting and propellers, including the air and circulating pumps which were driven off the L. P. shafts, was only 66 tons, or 42 pounds per H. P., a gain in weight similar to the 70 tons saved by adopting turbines in place of reciprocating engines in the Lorena, also of 3,500 I. H. P.

In the channel steamers, a fair weight for the respective systems may be taken as about 85 pounds per I. H. P. for piston engines against 60 for the turbine, for all weights of actual propelling machinery aft of the forward engine room bulkhead.

The following figures show the machinery weights of the Midland Railway Company's steamers:

Vessel.	Engine.	Total weight.	Boilers.	Engines.	Shafting and propellers.	I. H. P.	Lbs. per I. H. P.
Antrim and Donegal..	R	730	460	215	65	6,500	96.6
Londonderry	T	575	390	160	25	6,500	63.7
Manxman	T	655	460	195	195	8,000	54.6

That is to say, the weight of the reciprocating engines of the Antrim (whose builders, Messrs. John Brown, are amongst the most experienced channel boat designers that there are), was about 76 percent more than that of the turbines of the Manxman, and 52 percent more than that of the Londonderry's. Certain hull weights being saved in keelsons, shaft bossing, etc., in the turbine steamers, brought the total saving in weight to 6 percent of the displacement of the entire ship. In comparing the Antrim and Londonderry, it must be remembered that the boiler pressure in the former was 200 pounds against the latter's 150; that is, if the Antrim's had been 150 pounds too, the boiler weights would have had to be still larger in order to cope with the increased consumption, while the engine weights would have been greater, too, due to the larger cylinders necessary with the lower pressure.

In the Amethyst and Topaze, the total machinery weights were kept the same, in spite of a slightly lesser weight of engines only in the Amethyst. The total weight of machinery for each vessel was practically 535 tons, on which the turbines developed 14,000 H. P., and the piston engines only a bare 10,000. The bunker capacity in each vessel is about 750 tons maximum, and Fig. A is a fairly accurate guide to the relative radius of action.

Comparing the Viper with the reciprocating engine destroyers of the same dimensions (viz: 210′ 0″ long x 21′ 0″ beam), the turbine propelling machinery of 12,000 H. P., with condensers and pumps, shafting, and propellers weighed about 73 tons, while the same details for the 6,000 H. P. piston engines were rather over 80 tons. A larger destroyer of 9,500 H. P., designed for 33 knots—H. M. S. Express—had about 115 tons devoted to this, making the weight per horse power 27.1; the 30 knotters being about 30 pounds, and the Viper's 13.6. To compensate for the lighter engines, various other portions, especially in the stokehold, were increased in weight, and the total for engines and boilers, with water and auxiliaries connected with propelling, was about 30 tons more than that of the 30 knotters, and 20 tons less than that of the Express, whose actual speed was 31.0 knots.

In view of the proposed 36 knotters for the British

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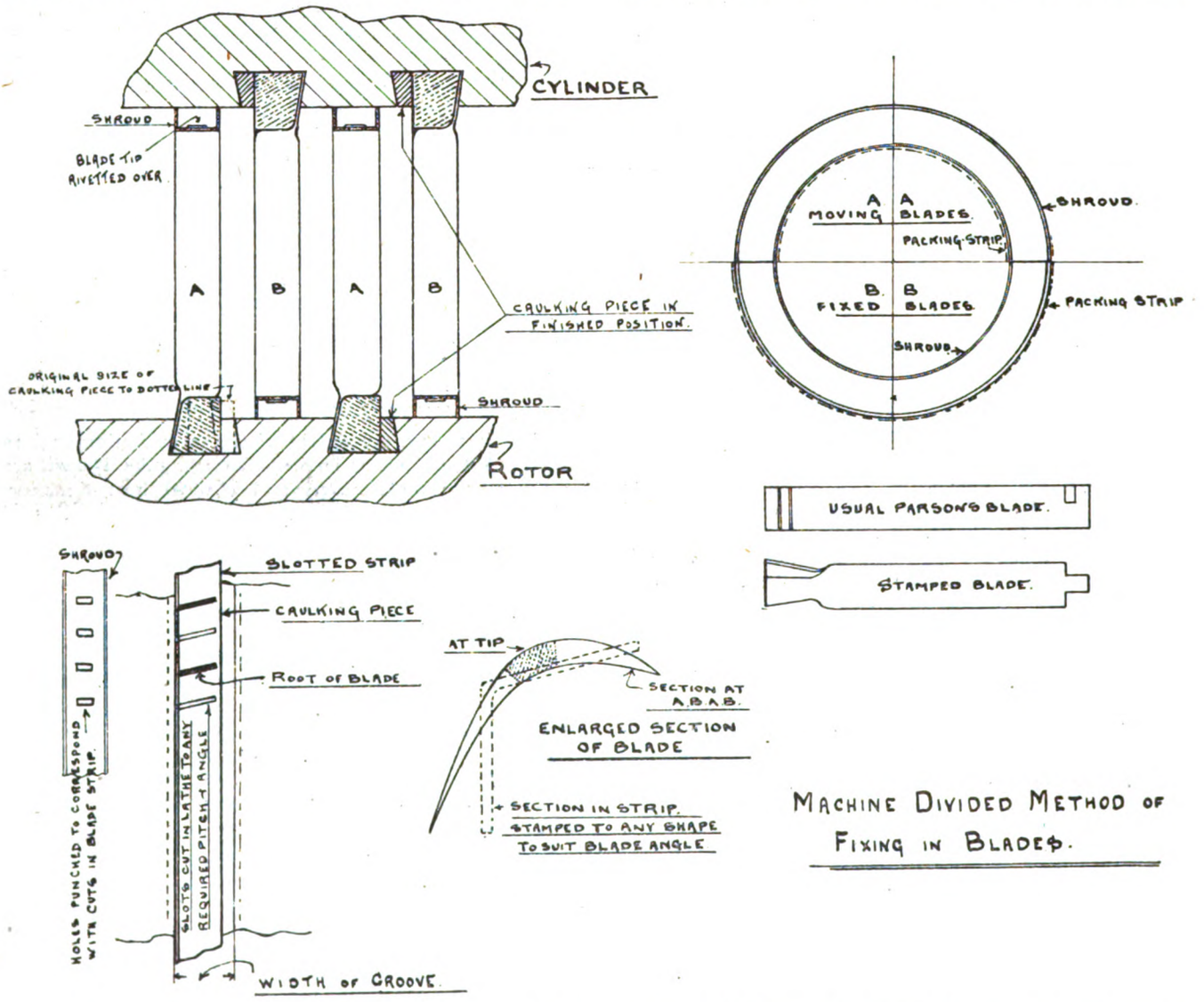
Government, these figures are of interest; of twice the power of the piston engines in vessels of the same size and shape, the Viper's engines weighed 8 percent less and occupied the same space. Reciprocating engines of that power could not have been made for that speed (1) on account of weight required affecting the displacement, and of this reacting on the power necessary, and (2) on account of propeller difficulties, due to cavitation, limiting the speed of rotation, which would have affected the weight still more. When the power is increased yet further, the inability to construct piston engines becomes even more apparent, and it is obvious that the peculiar property turbines possess in that their size is affected only by the revolutions and the pressure, and very slightly by the power developed, is extremely valuable. When, as in these 36 knotters, the proposed power is 28,000, equal to the Lucania, or twice that of the Baltic, recourse must be had to the turbine.

III. The complete absence of vibration from the main engines has many advantages, The deleterious action on the structure of the ship, the discomfort to passengers, the malicious effect on gun fire, and in many cases the impossibility of running the engines at their proper speed due to vibration, have resulted in treatises on engine balancing by numerous very talented authors. When an evil necessitates such notice as has been bestowed on it—and the transactions of this Society bear witness to the difficulty of eradicating it—it must be fairly serious. Unless a turbine is balanced it will not run properly. It was found on some of the early vessels fitted with multiple screws that the propeller vibration was very objectionable, but this was chiefly due to the high speed and proximity of the forward screws to the hull.

The recent tendency to use slower speeds and only one screw per shaft, and that one considerably further from the hull than in ordinary practice, has entirely eradicated this evil. Experiments made by Schlick on the Deutschland show that the material effect on balance that the varying intensity of the wake possesses is very marked. This effect is the only one likely to cause vibration in turbine work, but the smaller diameter of screws used means a less varying intensity over the disc area than is the case with ordinary propellers.

IV. The reduced cost of attendance and overhauling that can be obviated amounts to a larger proportion. When once adjusted and closed up, the lack of reciprocating motion, and the great reduction in the number of bearings, reduces both the attention necessary and the quantity of oil required. Supplied under a pressure of 6-8 pounds, large oil coolers are necessary on account of the cylinder heat being communicated to the bearings; these may run at a temperature of 110 degrees to 140 degrees F., and ample oil must be supplied. It can be used, however, again and again, the bearings all being en-



MACHINE DIVIDED METHOD OF FIXING IN BLADES.

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closed, and, as an instance of oil economy, the Queen Alexandra may be mentioned, her consumption being under one barrel for the whole season, say 4 or 5 months. Similiar instances are obtainable from the other vessels.

Slight deficiency of good maneuvering qualities in the early turbine steamers has been condemned by some, but it has been due in almost all cases to the amount of power provided for astern working. In more recent vessels, where a larger proportion has been supplied, the maneuvering qualities have been stated by many competent authorities to be excellent and quite equal to twin screw vessels with reciprocating engines, and under certain circumstances to paddles. The astern speed of the Queen was 13 knots and this has been increased to 15 in the sister ships on the same service, and to 16 in the Princess Elizabeth. Careful maneuvering trials were carried out with the Dieppe, and also with the Admiralty vessels, the Amethyst being tried against her sister ship, Sapphire.

The reversing turbines are incorporated with the L. P. spindles and revolve idly in the exhaust casing when the engines are running ahead. It must be noticed that there is no further complication involved by this, only a slight addition to the length of the turbine and a few more rows of blades. It is usual to make this turbine of the same diameter as the high pressure one and to obtain the power on smaller dimensions, slightly reducing the efficiency.

The real inferiority is in maneuvering from rest, especially from alongside a dock wall, but judging from the reports which have occasionally been made one might be led to believe that nothing worse than inward-turning ordinary screws could be devised. Against this defect may be set the fact that the reduced diameter decreases the risk of fouling the blade tips.

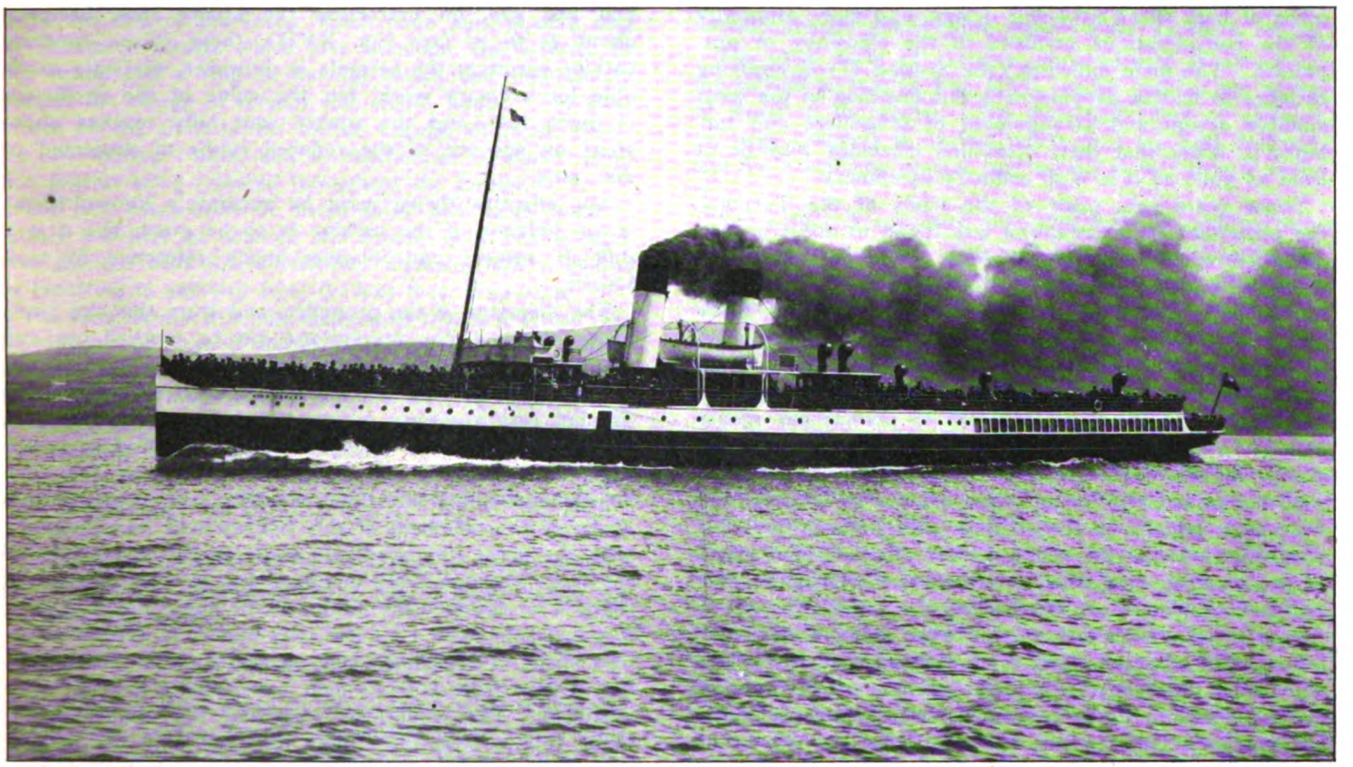
Reduction in space occupied may be of comparatively small moment in vessels taxed on under deck capacity minus a liberal allowance for engine space, but reduction in overhauling cost in large steamship lines is gladly welcomed, and the admitted reasons for the bold application of turbines in the Allan liners are absence of vibration and reduction of overhauling costs. When, as in the Queen Alexandra, turbine covers are not lifted for two years, repair lists will be enjoyable reading compared with the present voluminous documents.

The great reduction in number of parts in an engine cannot fail eventually to reduce manufacturing cost.

Regarding working cost and overhauling, no increase of consumption results in a Parsons type of turbine due to length of service, such as occurs in reciprocating work from wear of valves and pistons. The machine once made and closed up retains its original economy (provided there is no accident, of course) within limits of errors of observation.

These several features result in a considerable gain in commercial efficiency.

Assuming that it is settled that a battleship of 20,000 H. P. is to be engined with turbines. The economy (compare Amethyst and Hindustan or Dominion) will be better, and while the saving in weight will perhaps not be as marked as in the channel steamers, it will at least be 10 percent for the engines and shafting. As to boilers, the reduced consumption enables greater power to be obtained from the same weight, or the same power from less weight, and the same arguments apply to the coal supply. In the Atlantic manoeuvres, in 1903, extensively carried out by three large British fleets, an engine-room record of all mishaps and repairs necessary was kept. Of 12 first-class battleships and cruisers materially inconvenienced by engine defects (many of them very minor, but still inconvenient), in 8 these defects were in portions that could not occur in turbine installations owing to their absence. (Twelve vessels may seem a large number, but seeing that 70 large vessels, apart from torpedo craft, were engaged, it is a small proportion.) The height of the armored deck can be reduced owing to the reduced height of engines; the reduction in size of propellers is an appreciable advantage when draught of water



TURBINE STEAMER KING EDWARD.

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is a limiting consideration in the design of warships, while in torpedo craft the tiring effect of vibration on the crew, which is so well known where piston engines are concerned, is entirely eliminated.

The adoption of turbine machinery and higher speeds in the large warships of the Royal Navy has been accompanied by material advantages on these lines, but what value these assume in the eyes of naval authorities in this country will, I trust, be indicated in the discussion.

III. DESIGN.

The determination of the various dimensions of turbines and propellers to ensure a given result involves considerable calculation, but may be made with great accuracy.

The primary step is the estimate of highest rotary speed suitable in order that the turbine may be made as small as possible for any given efficiency, the calculation of propeller dimensions necessitating considerable experience of high speed propeller design, and more especially of the considerations involved in the efficiency of propulsion. The main difficulty (See Section II) in applying turbines to marine propulsion is this question of the most suitable design and arrangement of propellers and turbines in order that their combined efficiency may be at least as good as it is with ordinary machinery.

Some years ago, prior to the trials of the Turbinia, the phenomenon of cavitation was found to occur in propellers driven at very high speeds. It is due, partly, to excessive peripheral speed of blades and partly to excessive thrust pressure per square inch of projected blade area. The speed limit beyond which cavitation appears is about 12,000-13,000 feet per minute, while the pressure limit varies considerably with the shape and section of the blade, but is between 10.5 and 12 pounds per square inch at 12 inches immersion of tip. Beyond this, there is a very rapid drop in propeller efficiency due to increased slip, and to obviate this sufficient blade area is absolutely necessary, which, in conjunction with various practical proportions, limits the rotary speed. Much higher ratios of projected to disc area than were ever attempted with ordinary propellers are used in turbine work in order to reduce the diameter as far as possible, many vessels having ratios of about .5. The pitch ratio adopted is likewise much finer than usual in order to increase the revolutions, being from .8 to 1.0 in vessels between 17 and 25 knots; but for very high speeds, nothing under 1.0 should be used. The Turbinia's was about 1.3, and the channel steamers .9.

The slip varies considerably; in some vessels it has been brought quite low, down to 15 percent, but more generally it is between 17 and 27 percent. (Amethyst, 17 percent at full speed; Manxman, 24 percent; Viper about 28 percent.)

The tip speeds that have been used reached a maximum in the Viper's 12,350; the Amethyst was about 10,100 on the wing screws, and the Londonderry, 11,760. These are all very high, but many turbine vessels have not exceeded 9,000, which is quite in line with ordinary destroyer work. The pressure at which cavitation commences is also variable; probably it begins at about 10 pounds per square inch, and may reach 13 or even 14 pounds without any abnormal effect on the speed, but the slip will be very high and the efficiency low.

Exhaustive analyses of trials made by the author go to show that this pressure has varied in reciprocating engine work from 5 pounds to about 10, averaging approximately, when corrected to 12 in. immersion, 1 pound for every 1,000 feet per minute tip speed of propeller. (See Fig. VI.) In turbine work, about 10-12 pounds, according to service of vessel will be found to give results.

This pressure is the mean pressure per square inch of projected blade area, and is due to the effective thrust. It follows, then, that the greater is the propulsive efficiency for a given I. H. P. the greater the blade area required will be. The best shape of blade seems to be the symmetrical circular one, as shown in Figs. A, B, and C, Plate 18, but it is still undetermined.

I have advised the following formula for giving the diameter of turbine propellers direct, but it is obvious that much care must be bestowed on the design to obtain the best results.

Diameter of propeller in feet

$$= \sqrt{\frac{\text{Effective thrust in lbs.}}{\text{Coefficient.}}}$$

$$= \frac{\sqrt{\text{Thrust}}}{c}$$

The coefficient is a compilation of pressure, area, ratio, and 144, and, on extracting the square root, becomes about 24 to 30 (see Fig. XVII), these values covering turbine practice; the formula is, however, perfectly available for ordinary work, but the value of the coefficient is much less, and the square root only reaches about 16-21 on account of the reduced ratios of projected to disc area.

The effective thrust must be accurately known if the steam balance of the turbine is to be good, but it is a difficult subject and involves much reference to tank results.

The diameter of the propeller, and from this the pitch, being obtained, the revolutions can be worked out and the turbine dimensions then arranged.

Assistance from tank work is not only extremely helpful, but very necessary in many cases, especially for large vessels, for not only does knowledge of effective power materially assist in the design of propellers, but tank experiments alone will determine the best shape of hull. Many of the members of this Society will be conversant with the great improvements made in the stern lines of the large German mail steamers due to tank trials, and there is no doubt in the design of the new Cunard vessels, it would have been a far less easy matter to determine the best shape of afterbody, and especially of the shaft bossing, if data from copious tank experiments had not been available. The conditions regarding the application of triple screws have been quite modified with the smaller diameters employed with the turbine; decreased augment of resistance compared with twin screws, is found to accompany their application, due largely to the greater distance from the hull and the largely reduced disc area, whereas with the larger diameters usual in ordinary work the reverse is the case.

Regarding the actual arrangement, it is hard to generalize. Where possible, three screws seem to give the most satisfactory results in fast vessels, both for turbine and propeller efficiency. To enable higher revolutions to be obtained and to reduce the size of cylinders necessary, four shafts may be used, as in the large Cunarders, but such a course adds to the complexity, though diminishing the constructional difficulties encountered in cylinder design. An arrangement of two shafts has only been attempted in one small yacht, and is not to be recommended for Parsons turbines; it is, however, doubtful if it is possible to adopt the efficiency in large vessels with any present design of turbine. Four shafts are practically necessary in large naval work, but for smaller cruisers and torpedo craft three may be used—it is largely a matter of judgment according to circumstances.

Except in rare cases, where, to obtain higher revolutions and consequently less weight, some economy may be sacri-

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ficed and two screws used, only one propeller per shaft should be adopted.

Before leaving this subject, it may be as well to impress on those undertaking such designs, and while excellent results can be and have been obtained with this system of propulsion, it is only by very careful attention to the design and arrangement of propellers for efficient working it is impossible to assume revolutions and later on to design a propeller to suit.

The determination of the details of blading arrangements to secure the best results also necessitates considerable practice; there are few formulae for guidance, such as are found in reciprocating engine work.

The general features of the design and the action of the steam in the blades of a Parsons turbine is, probably, well known to most of the members here. The total expansion of the steam is approximately adiabatic, and is subdivided into a number of steps, in each of which is maintained a certain dynamic relationship between the steam speed and that of the vanes. Each stage consists of a ring of stationary blades, which give direction and velocity to the steam, and a ring of moving blades that immediately convert the energy of velocity into useful torque. The total torque on the shaft is due to the impulse of steam entering the moving blades, and to reaction as it leaves them, this process being repeated throughout the turbine.

The best relationship of steam speed and blade speed is largely a matter of opinion, and equally good results have been obtained with wide differences. Probably little is gained by departing in any way from the best theoretical value.

The vane speed VT is, like many other things, provided that the number of rows of blades is correct, a matter of convenience and is modified by experience; wide differences in this also can be made without tangibly affecting the efficiency. Assuming a speed such as is given in table 1, the diameter of the turbine is found from the formula:

$$\text{Diameter} = \frac{\text{Blade velocity in ft. p. sec.} \times 228}{\text{R. P. M.}}$$

The velocity acquired by the expansion of steam ($=VS$) may be found by calculating the B. Th. U. drop between the two pressures, whence,

$$VS = 223 \sqrt{\text{h. U.}}$$

The ratio of blade speed to steam speed being settled, the drop at each row may then be determined, which will give the number of rows of blades required, since the initial and terminal working pressures are known. No formula such as $\frac{\text{P. L. A. N.}}{33,000}$ exists for determining the main dimensions, but experience has shown that there are various formulae which can be arrived at from past practice, which will give a very suitable combination of dimensions. Such methods are the result of long and costly experiments, and it is scarcely surprising that builders should forbear to publish them.

The blade velocity adopted in practice varies largely according to the class of work; generally it is much lower in marine work than with the high revolutions that are adopted for generators in electrical work. While that for marine turbines can barely exceed 200 feet per second as a maximum, without great sacrifice of propeller efficiency, it is more usual to adopt a far lower speed, say 100 to 140 feet per second. The Rateau and Curtis types of turbine require far higher velocities, the former about one and one-half times and the latter at least twice these speeds, and in marine work it is almost impossible to obtain them.

The blade heights are made variable to allow for the expansion of the steam and the desired adjustment of velocities throughout the turbine necessitates intricate calculation, involving more space than is at the author's disposal.

The width and pitch of the blades are partially arbitrary and, to some extent, a matter of strength and convenience. Ample longitudinal clearance can be allowed, varying in practice up to ¾ in. with large blades, but the tip clearance is more important, and must be made as fine as possible. The blade tips are usually ground up and their diameters made accurate to thousandths of an inch; clearance depends largely on temperature and diameter, and varies in amount from thickness of a dime to that of a dollar.

The blade heights should vary from about 4 percent to 14 percent of the mean diameter, in which case this clearance only represents a very small percentage of loss. Various metals have been used for the blading; generally a form of cheap brass has been employed for both blade and packing piece. Steel blades have been used in this country, while the best metal yet found for work with high temperature steam is an alloy containing 80 percent of copper and 20 percent of nickel, this being especially strong and durable, though almost pure copper gives excellent results.

The usual form of caulking piece adopted is shown by the shaded portion in Fig. XXII, which outlines the action of steam in the blades. The distorting effect of caulking on large cylinders is distinct unless they are well designed, and the assembling process may appear slower than it really is.

The author is convinced that this form of caulking-piece must largely disappear in favor of a machine-divided strip, such as some firms are now using. This form of blading not only ensures perfect accuracy but is a remarkably cheap one, saving several processes over the old method. The slotted strip (see Fig. XXV) is associated with a shallow shroud ring into which the blades are fitted, being thus held at the tips as well, the whole arrangement forming a very strong and durable method of attachment.

As to blade-stripping, nearly every case may be attributed to carelessness in design, manufacture and operation. The unequal distortion of cylinders by heat—a matter of great importance in marine turbine work where flexible shaft couplings are impossible—accounts for most stripping; the passage of grit or water is not so formidable as might be imagined. Any whipping of the turbine spindle will destroy the tip clearances (and the blades too), but careful design should never permit this; defective or unsuitable blade material is another preventable cause, and there is also the possiblity of bad workmanship. In a properly designed and well-made turbine the chance of blade-stripping is very minute.

The bearing pressure permissible in marine turbines is about 80 to 90 pounds per square inch; the circumferential speed of the shaft, however, must be kept down to about 25 to 30 feet per second, if such a pressure is used; in electrical work 50 pounds and 50 feet per second is more usual. Under these conditions and with ample oil supply the necessity for adjustment will be very rare. Rigid bearings, lined with white metal, are used.

The centrifugal stresses are very low in marine turbine spindles; in fact about 200 feet per second is practically the highest vane speed obtainable, in which case the stress will not exceed 4,000 pounds per square inch, but usually it is very much lower.

The propeller thrust is balanced by the action of the steam in a very satisfactory manner, but this calculation involves knowledge of effective thrust along the shaft in order to accurately proportion the annular area on which the steam pressure is to act. The result is that the spindle is in compression and the cylinder in tension when the turbine is working; a margin is always allowed so that the propeller thrust exceeds the steam thrust.

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Owing to the unfortunate propensity of iron and steel to expand when hot, care must be taken to allow the resultant movements to take place freely; the after end of the cylinder is secured to the ship, and through it is transmitted the propeller thrust, while the other end slides forward. The warming up of large turbine cylinders requires considerable care.

Governing is largely unnecessary in marine work, as the fly-wheel effect of the motor tends to prevent any sudden fluctuation in speed, even if the greater immersion of the propellers does not prevent racing.

The radiation from the low-lying turbine cylinders is sometimes very unpleasant, and in warships, with their low armored decks, ample ventilating facilities are necessary. No method exists of indicating the power, such as is possible in piston engine work, but the determination of brake horsepower can easily be made with great accuracy; in electrical work a water brake is simplest, while the electrical torsion meter invented by Messrs. Denney and Johnson, allows an easy method of arriving at the B. H. P. in marine turbines, and, unlike the water brake, can be applied when the turbine is at work.

Regarding the vexed question of efficiency, it is obvious that no such large loss of power due to engine friction exists with turbines as it does in reciprocating engines. Then again, the small propellers used are driven very hard at full speed, and at lower speeds their efficiency increases; it falls off in piston-engine work due to excessive size.

Where the effective horse-power is unobtainable from tank trials, it is usual to take a similar propulsive coefficient to that found in corresponding classes of piston-engine practice.

The turbine efficiency remains constant over a wide range of size, while the propeller efficiency increases distinctly with lower thrust pressures and larger dimensions for the work to be done. The weight of the turbines, however, varies approximately as the inverse square of the revolutions.

CONCLUSION.

The author must beg of much leniency on the part of members for the length of this paper.

The application of a new form of motor is not to be undertaken lightly, and the author has in consequence tried to embody as many facts as possible. He is well aware that innumerable subjects of interest in the adoption of such a system have been passed over or insufficiently touched upon, but the whole subject is new to the transactions of this society, and while portions of the paper may be of less interest than others, it is possible that it may be useful to have them on record in this country. It is hoped that the photographs and diagrams will, to some extent, explain what has not been touched on in the text.

If there seems any tendency to exalt the turbine unduly, it must be dismissed from consideration; the reciprocating engine is by no means obsolete. It has played a most useful part in the world's engineering, and if it should happen that it must go before the rapid advance of the rotary engine—and for many classes of vessel it is already supplanted—it may be remembered that sails had to make way for pistons, and that while the American cup is still to be won it is unlikely that they will disappear entirely.

APPENDIX A.

The following figures relative to the performance of the King Edward were given by Mr. James Denny, in the course of a speech made at the launch of the Queen Alexandra, April 8, 1902. If the King Edward had been fitted with balanced twin triple expansion engines of the most improved type, and with her existing boiler, the displacement would have been slightly increased to carry the extra weight of the piston engines as compared with turbines. Under these conditions the best speed obtainable would have been 18.7 against the actual 20.5 knots of King Edward; of this increase of speed .2 was due to lesser displacement, while .6 was due to the superior efficiency of the turbine and its accessories. While the difference between 19.7 and 20.5 knots corresponds to a gain in I. H. P. of 20 percent in favor of the turbine steamer, it would have been barely possible to drive the King Edward at all at 20.5 knots with ordinary engines owing to the extra weight, the necessarily increased displacement.

Comparing the King Edward with the Duchess of Hamilton, a modern paddle steamer owned by the same company, and of practically the same dimensions, we have the following record in favor of the turbine for the three months working.

	King Edward.	Duchess of Hamilton.
Total coal burnt, tons	1430	1759
Miles run	12,116	15,604
Miles per ton	8.47	8.87
Number of days running	79	111
Daily average, coal	18.1	15.85
Average speed, about	18.5-19.0	16.5

It is impossible to indicate turbine engines of course, but from the speed, the approximate coal per I. H. P. in the King Edward is about 1.8 pounds per I. H. P. per hour. One would have expected the coal burnt per mile to have been much greater with the faster ship.

TOTAL IRON ORE MOVEMENT.

The total ore shipments by lake during 1905 were 33,476,904 tons, which is 12,250,313 tons in excess of the movement of last year. To these figures is yet to be added the all rail movement which will probably exceed 500,000 tons, so that the total movement of ore from the Lake Superior mines during 1905 will be 34,000,000 tons. The 1905 movement is, therefore, over 6,000,000 tons greater than the movement of 1902, which is the record-breaking movement on the great lakes. Of this great movement the Oliver Iron Mining Co. shipped 18,779,374 tons. Shipments during December aggregate 405,060 tons, an increase of 38,689 tons over the movement of the corresponding month last year. The shipments by months during the year have been as follows: April, 1,195,173 tons; May, 4,619,431 tons; June, 4,999,451 tons; July, 5,224,619 tons; August, 5,009,382 tons; September, 4,425,550 tons; October, 4,257,009 tons; November, 3,341,229 tons; December, 405,060 tons.

Following were the shipments by ports during the month of December and during the full season, with comparative data for the previous year:

Port	December 1904.	December 1905.
Escanaba	137,544	131,553
Gladstone	.....	.....
Marquette	40,410	52,578
Ashland	18,422	25,224
Superior	37,926	75,151
Duluth	75,599	39,853
Two Harbors	56,670	80,701
	366,371	405,060
1905 Increase		38,689

Port.	Season 1904.	Season 1905.
Escanaba	3,644,267	5,307,938
Gladstone	480	.....
Marquette	1,907,301	2,977,828
Ashland	2,288,400	3,485,344
Superior	4,100,000	5,118,385
Duluth	4,649,611	8,807,559
Two Harbors	4,566,542	7,779,850
	21,226,591	33,476,904
1905 Increase		12,250,313

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SUMMARY OF NAVAL CONSTRUCTION.

The monthly summary of construction issued by the navy department shows commendable progress on all naval vessels. Both the Connecticut and Louisiana are practically complete in a structural sense and will be ready to go into commission in a few months. Following is the summary:

Name of Vessel.	Building at	1905. % of completion. Nov. 1	Dec. 1
	BATTLESHIPS.		
Virginia	Newport News S. B. & D. D. Co.	95.31	97.00
Nebraska	Moran Bros. Co.	82.00	83.00
Georgia	Bath Iron Works.	89.00	90.15
New Jersey	Fore River Shipbuilding Co.	92.1	93.7
Rhode Island	Fore River Shipbuilding Co.	95.00	98.00
Connecticut	Navy Yard, New York.	91.3	92.66
Louisiana	Newport News S. B. & D. D. Co.	89.25	92.56
Vermont	Fore River Shipbuilding Co.	65.8	68.7
Kansas	New York Shipbuilding Co.	64.9	67.7
Minnesota	Newport News S. B. & D. D. Co.	75.41	77.10
Mississippi	Wm. Cramp & Sons.	43.31	45.74
Idaho	Wm. Cramp & Sons.	39.19	42.58
New Hampshire	New York Shipbuilding Co.	25.00	29.2
	ARMORED CRUISERS.		
California	Union Iron Works.	84.3	86.2
South Dakota	Union Iron Works.	83.2	84.9
Tennessee	Wm. Cramp & Sons.	87.80	90.02
Washington	New York Shipbuilding Co.	87.9	89.4
North Carolina	Newport News S. B. & D. D. Co.	23.13	26.77
Montana	Newport News S. B. & D. D. Co.	19.21	22.29
	PROTECTED CRUISERS.		
St. Louis	Neafie & Levy S. & E. B. Co.	81.28	83.62
Milwaukee	Union Iron Works.	84.01	86.00
Charleston	Newport News S. B. & D. D. Co.	99.9	99.9
	TRAINING SHIPS.		
Cumberland	Navy Yard, Boston.	95.00	95.00
Intrepid	Navy Yard, Mare Island.	97.5	97.5
	SCOUT CRUISERS.		
Chester	Bath Iron Works.	9.00	13.27
Birmingham	Fore River Shipbuilding Co.	12.6	15.4
Salem	Fore River Shipbuilding Co.	12.3	14.8
	TORPEDO BOATS.		
Goldsborough	Wolff & Zwicker.	99.00	99.00
O'Brien	Lewis & Nixon.	99.00	99.00
	SUBMARINE TORPEDO BOATS.		
Submarine T. B. No. 9,	Fore River Shipb'ing Co.	30.6	43.5
Submarine T. B. No. 10,	Fore River Shipb'ing Co.	29.00	36.9
Submarine T. B. No. 11,	Fore River Shipb'ing Co.	29.3	37.00
Submarine T. B. No. 12,	Fore River Shipb'ing Co.	25.00	33.6

STORAGE CAPACITY IN CANADIAN ELEVATORS.

Fort William, Ontario, Dec. 20.—The total grain storage capacity of the Canadian head of the lakes, with all houses completed and no more in contemplation for early construction, is as follows:

Canadian Pacific Railway, House A	1,250,000
Canadian Pacific Railway, House B	2,500,000
Canadian Pacific Railway, House C	1,500,000
Canadian Pacific Railway, House D	3,500,000
Canadian Pacific Railway, House E	1,000,000
Canadian Northern Railway, House No. 1	6,500,000
Empire Elevator Co.	1,500,000
Ogilvie Milling Co.	600,000
J. C. King Elevator Co.	1,250,000
	19,600,000

All of this capacity, aside from the 7,750,000 bushels of the C. N. Railway and the King house, is at Fort William.

At Duluth-Superior there is a total capacity of 34,000,000 and at Washburn 1,500,000 bushels, making a total of 55,100,000 bushels storage capacity at the western end of Lake Superior.

The winter finds comparatively little grain in store at these various points, at Duluth only about 7,500,000 bus., at Washburn none at all, and here nearly as much as at Duluth. The fall's shipments from all ports, all grains, have been 78,500,000 bushels, this from August 1, which is the commencement of the new crop year at Duluth, though here the usual time set is Sept. 1.

CLEVELAND CLIFFS ORDER THIRD STEAMER.

The Cleveland Cliffs Iron Co. has just given an order for a third steamer to the Great Lakes Engineering Works of Detroit, making three steamers that it is to build for this company. The third vessel will be a duplicate of the other two and will therefore be 550 ft. over all, 530 ft. keel, 56 ft. beam and 31 ft. deep. She will be given the same power as the other two, which is somewhat in excess of that possessed by steamers of their type. The new steamer is to come out next September.

WRECKING OPERATIONS ON LAKE VESSELS.

Wrecking operations are now in progress on the steamer Crescent City ashore near Duluth. Capt. W. W. Smith of the Pittsburg Steamship Co., who is in charge of the operation, has wired that he has found a rock 4 ft. up through the bottom of the Crescent City. It will be necessary to blast it down to a level with the bottom of the ship before she can be pulled off. Work on the Mataafa and Manila will be started at once as they are exposed to danger from the sea. The Edenborn will be attended to later. The Reid Wrecking Co. is doing the work. The only vessels of the Steel Corporation which were total losses are the steamer Lafayette and barge Madeira.

AROUND THE GREAT LAKES.

The Cleveland & Buffalo Transit Co. has enjoyed a very profitable season, and at a meeting of the board of directors last week, decided to pay an extra dividend of one percent. The extra dividend is payable Dec. 30.

Twenty-nine feet of water was found by soundings where the Mataafa and Elwood struck bottom outside the Duluth entry, and as they both hit the bottom very hard, the height of the waves during that memorable storm of two weeks ago can be well appreciated.

The berths and frontage of the Superior Ship Building Co. are filled with ships. There are 26 of the fleet of the Pittsburg company alone tied up there. The yards will be very busy all winter, and their only difficulty will be to get men to do the pressing work. In addition to the ships under construction the repair jobs will be tremendous and will take a large number of men working day and night. The yards were never so busy as they bid fair to be this winter.

The designs by Mr. Frank E. Kirby for a new steamer to be built for the Detroit & Cleveland Navigation Co. have been accepted by the directors of the company. The new steamer will be 440 ft. long and 91 ft. wide over guards. The vessel will have four decks with 313 staterooms and 22 parlors. An unusual feature will be an elevator for passengers. The steamer will be a side wheeler, having three cylinder compound engines of 7,000 H. P., steam being supplied by eight boilers. All the shipyards are being asked for bids.

Superintendent T. W. Kennedy, of the Lake Carriers' association, says that 1905 has been a very successful season along the docks for grain shovelers. The men are paid $2.50 each for every 1,000 bushels unloaded. It is estimated that the 700 men employed as grain shovelers unloaded 110,000,000 bushels of grain. Most of the shovelers will be kept busy until the latter part of January unloading vessels now in port.

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MAIDEN TRIP OF TURBINE LINER CARMANIA.

When the new Cunard liner Carmania sailed from New York on Saturday last every stateroom was filled. The great liner had over 2,600 passengers aboard in addition to her crew of 710 men. It is interesting to observe that space has been sold ahead in this ship until June next, proving conclusively that she is the most popular vessel afloat. Her maiden trip to this country under turbines was successful in every way. The great ship was put to a severe test because she came through in weather of such violence as to sink the Nantucket lightship. There was no vibration observable; nor even when the propellers got out of water was there any of the customary shuddering of the hull. Of course, it is too early to compile any data on operating costs and economy over the reciprocating type, and doubtless the company for the present has every reason to withhold such information. The salient thing is that the trip was successful in every way, that the engine worked without a hitch and that the passengers enjoyed a degree of comfort that is not possible on a steamer equipped with the common form of marine engine.

The Carmania is in every respect a sister of the Caronia with the exception that the Caronia has reciprocating and the Carmania turbine engines. Both were built at the Clydebank Works of John Brown & Co. and are 672½ ft. long over all, 72 ft. beam and have a moulded depth of 52 ft. Their gross registered tonnage is 19,524 tons and the draught in ordinary working condition is 33¼ ft. The installation of turbines therefore on a steamer of these dimensions is a matter of great importance. The boldness of this advance in marine turbine practice is indicated by the fact that the largest units previously made were of 78 tons weight for the Virginian and Victorian of the Allan Line, while the turbines for the Carmania weigh 340 tons each. A remarkable feature of the construction of this vessel is the great expense to which the builders went to experiment with turbines. The installation of turbines in the Carmania was really at the suggestion of John Brown & Co. as the Cunard Co. had originally intended to equip both the Caronia and Carmania with reciprocating engines. The builders erected on land a turbine output of 1,800 H. P. with all the accessories employed on board ship. In this way a testing plant was obtained which permitted very accurate measurements of the operating conditions of such machinery. Not only the steam consumption under different ahead and astern conditions, but also such special marine problems as the thrust of steam were investigated with great care. Plans had to be made also for overhauling the engines at sea and these problems were most significantly met by the builders. The Carmania made a trifle over 20 knots on her trial trip, which is a knot in excess of the speed made by the Caronia. Her average speed on her maiden trip was 17 knots. The *Marine Review* will, in its issue of Jan. 4, go extensively into a description of this great steamer.

TRIAL OF BATTLESHIP LOUISIANA.

The new battleship Louisiana was sent over a measured mile course near Owl's Head last week, and easily exceeded the government requirements of 18 knots an hour. The maximum speed developed was 18.924 knots, and her builders express confidence that the ship can attain a speed of 19 knots. The Louisiana was sent over the course twelve times. The first run was made at 8 o'clock in a drizzling rain, but later in the day the sky cleared and the sea was almost calm. Five miles were covered at top speed, but the average rate of speed was 18.61 knots an hour. The maximum number of revolutions was nearly 126 a minute, and the number necessary to maintain the required speed of 18 knots was estimated to be about 120. The anchor test took place immediately after the propeller test, and everything worked smoothly. Among the naval officers on board during the trial were Chief Naval Constructor W. L. Capps, Naval Constructor D. W. Taylor, who designed the Louisiana: Commander R. T. Hall, senior inspector of machinery, and Capt. A. R. Couden, who will command the battleship.

CHANGES IN MAINE'S TURRET GEARING.

Important changes have been made in the gearing of the turrets of the United States battleship Maine, and experiments in turret turning will be conducted on that ship this winter in the manoeuvers in Southern waters. There was a time when the efficiency of turret fire was considered as at its best when the turret could be turned in the shortest possible time.

The development of machinery for this purpose resulted in revolutions of one a minute, and it came about that in the rapidity of turning the quality of slowness in the operation of the turret was ignored. It now appears that there is a change of opinion regarding the turret gearing, and it is considered important not to encourage rapidity in turret revolution as much as to obtain slowness. In the new mechanism installed in the Maine the turret revolutions have been reduced to one in two minutes. This change is made on the theory of the strategist that it is desirable to keep the turret guns a longer time on the target, which would not be possible with the turret gear fixed at the present speed.

B. & O.'s NEW LOCOMOTIVES.

The Baltimore & Ohio Railroad is now receiving, at the rate of two per day, the first of the lot of 210 new consolidation freight locomotives, seventy of which are being built at the Richmond, Va., and 140 at the Schenectady, N. Y., Works of the American Locomotive Co. This order was placed the latter part of last April, in connection with an order for thirty-five passenger locomotives and five switching engines, and 10,000 freight cars at an aggregate cost of $14,000,000. It will give the road better and larger equipment than ever before in its history and enable it to meet the steadily increased demands of business and move the great volume of traffic promptly. President Murray has been anxious to get this equipment in service as early as possible.

The locomotives are of the general design, suitable for the economical handling of heavy tonnage at fast or slow speeds over level and mountainous, open and tunnelled railroad of varying curvature and gradient.

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The passenger lines operating out of Cleveland did an excellent business last year, the Cleveland & Buffalo Transit Co., carrying 120,154 passengers, and the Detroit & Buffalo line a great many more than that number. No lives were lost and not a passenger was injured during the season.

The new steamers W. G. Pollock and Joshua Rhodes which were ordered from the American Ship Building Co., by W. H. Becker, of Cleveland, will be operated by the Valley Transit Co.

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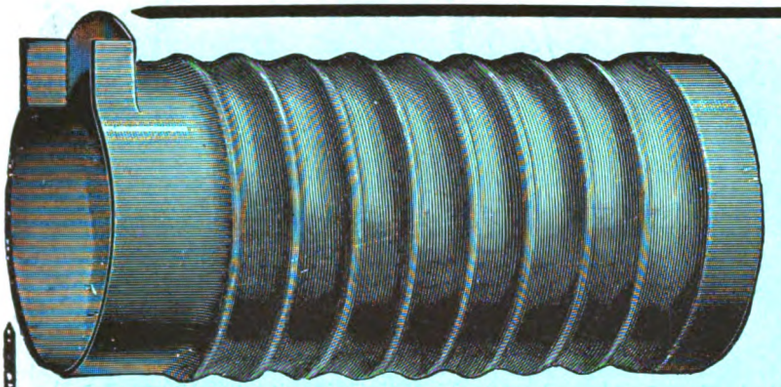

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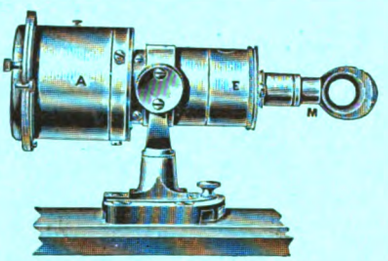

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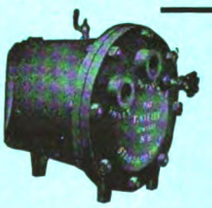

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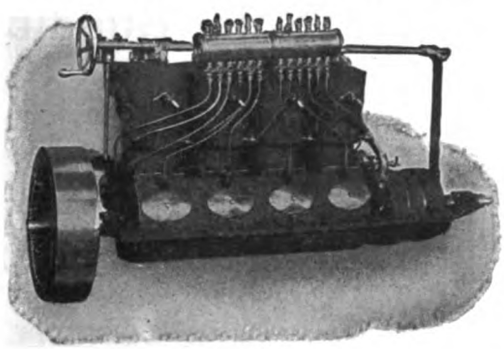

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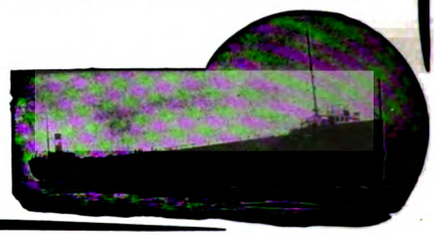

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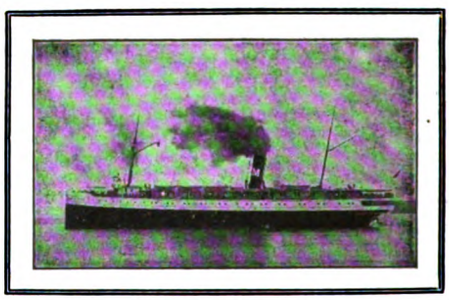

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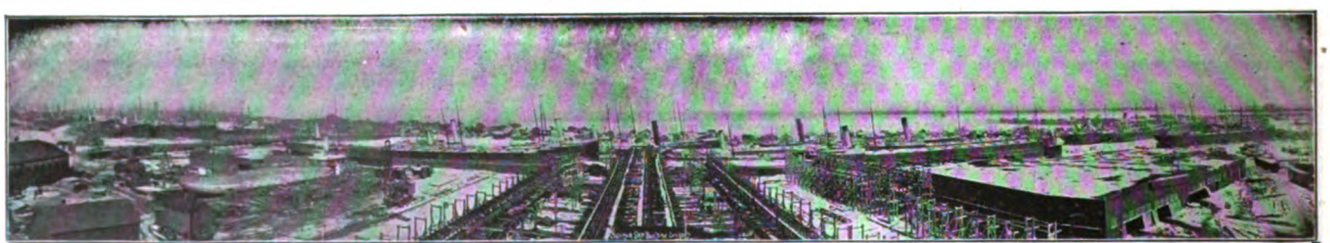

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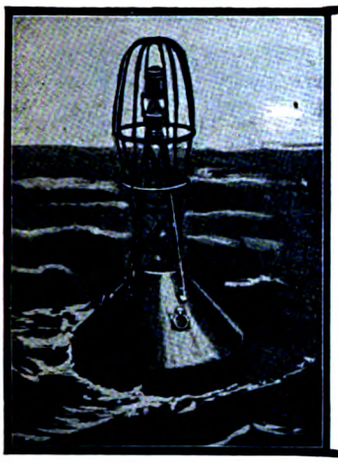

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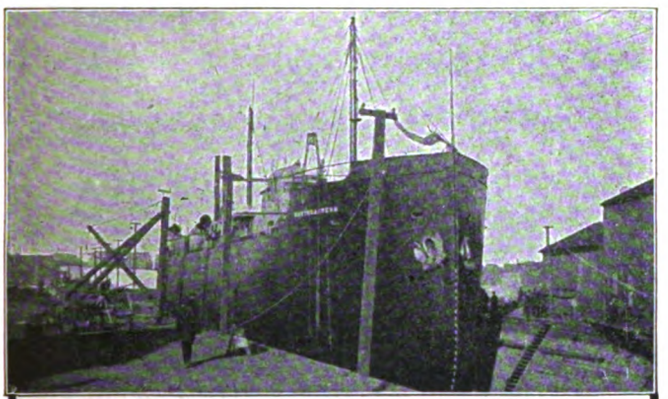

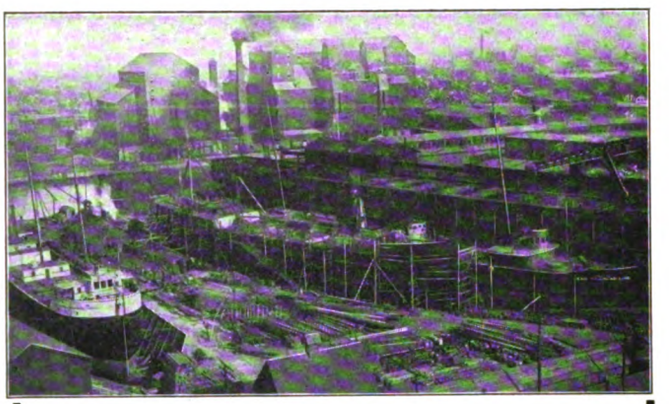

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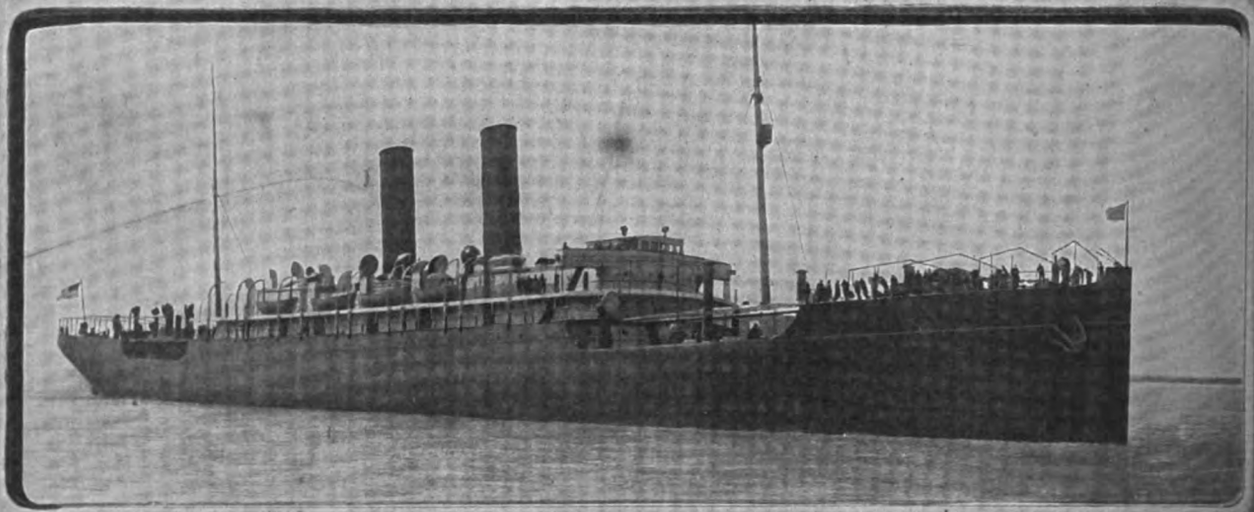

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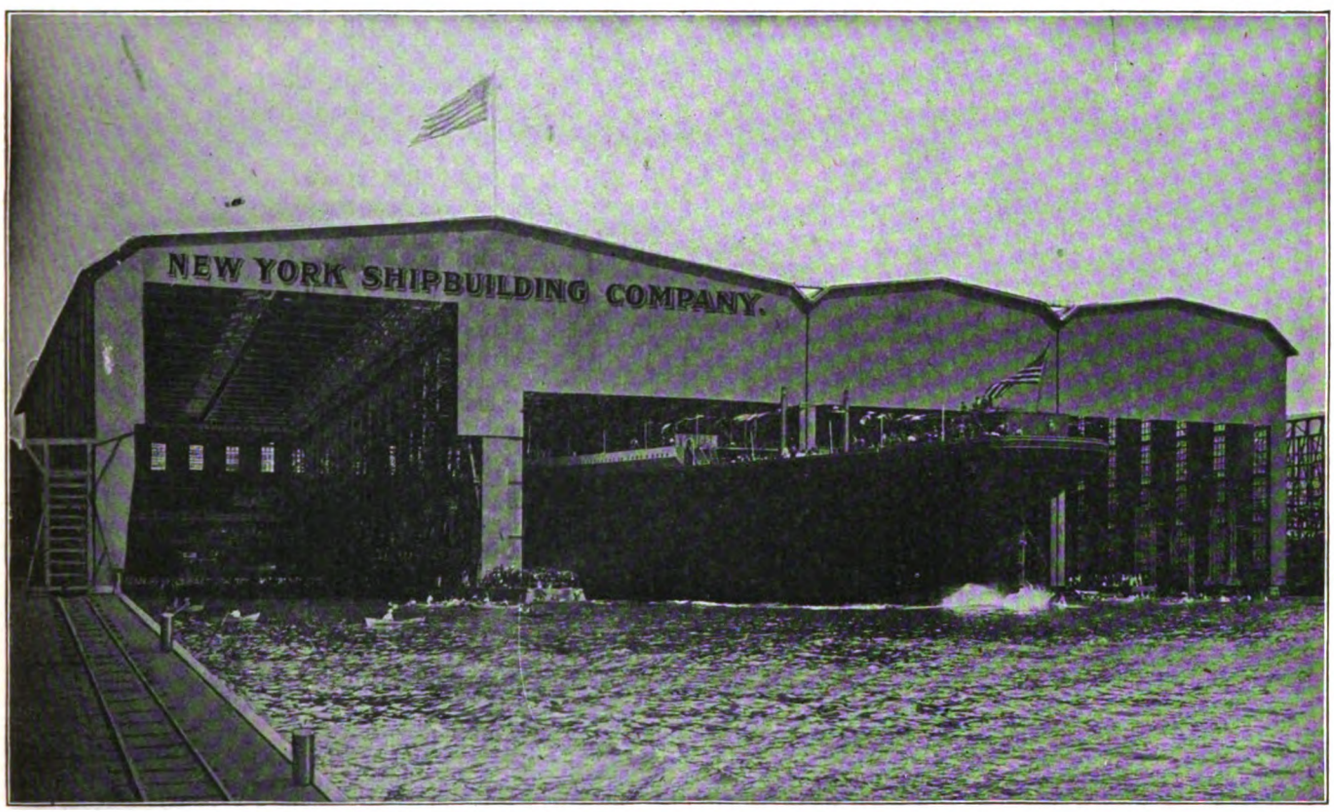

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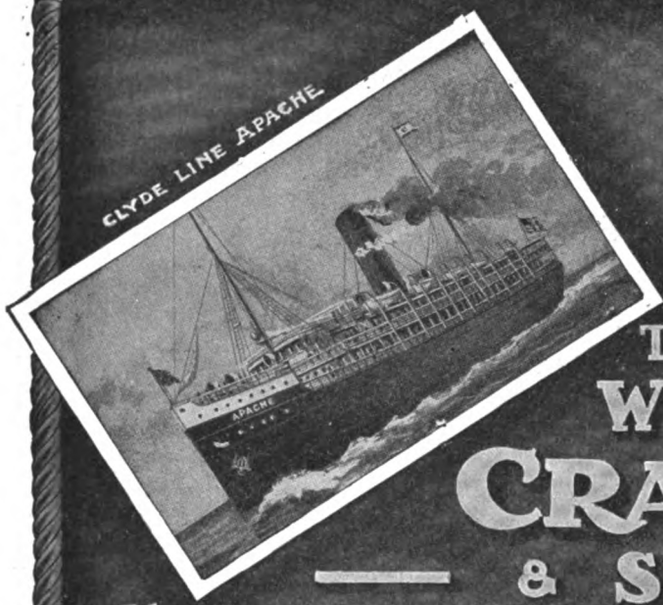

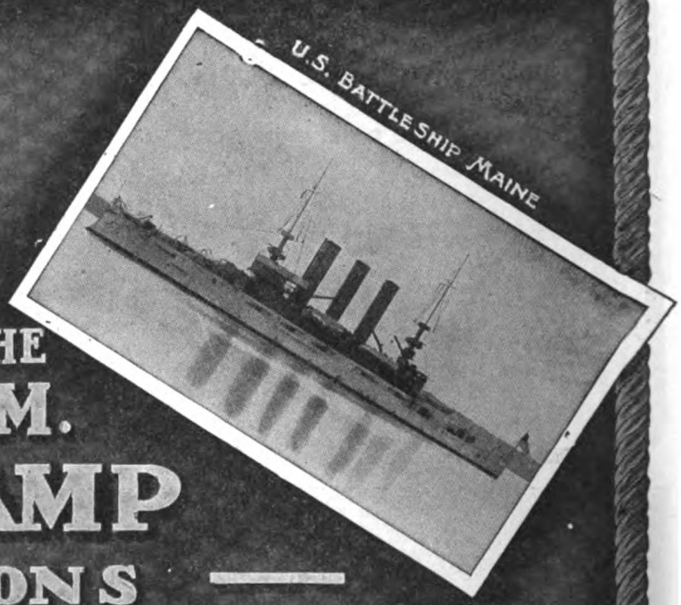

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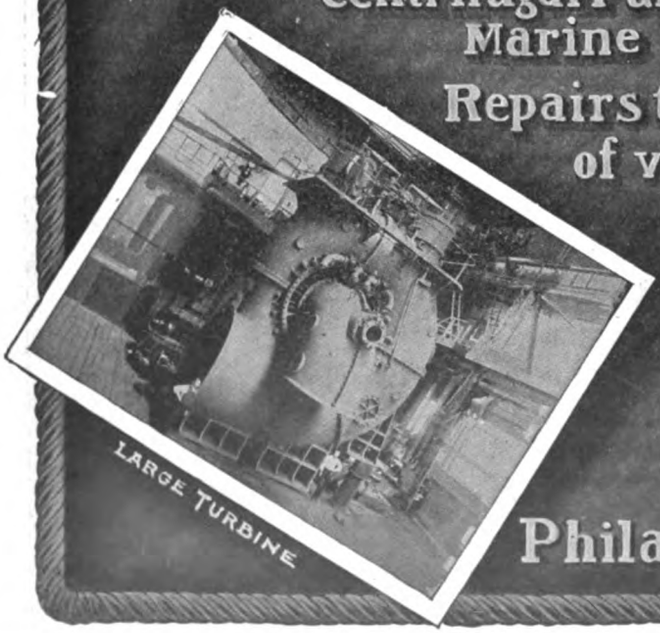

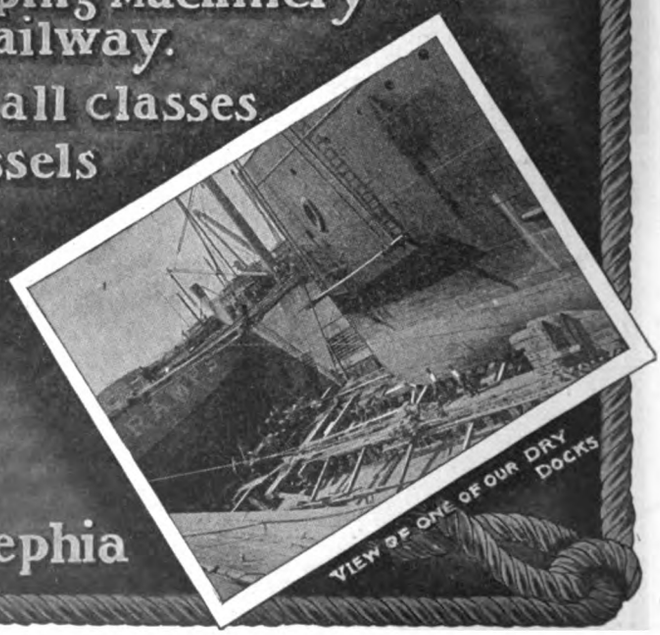

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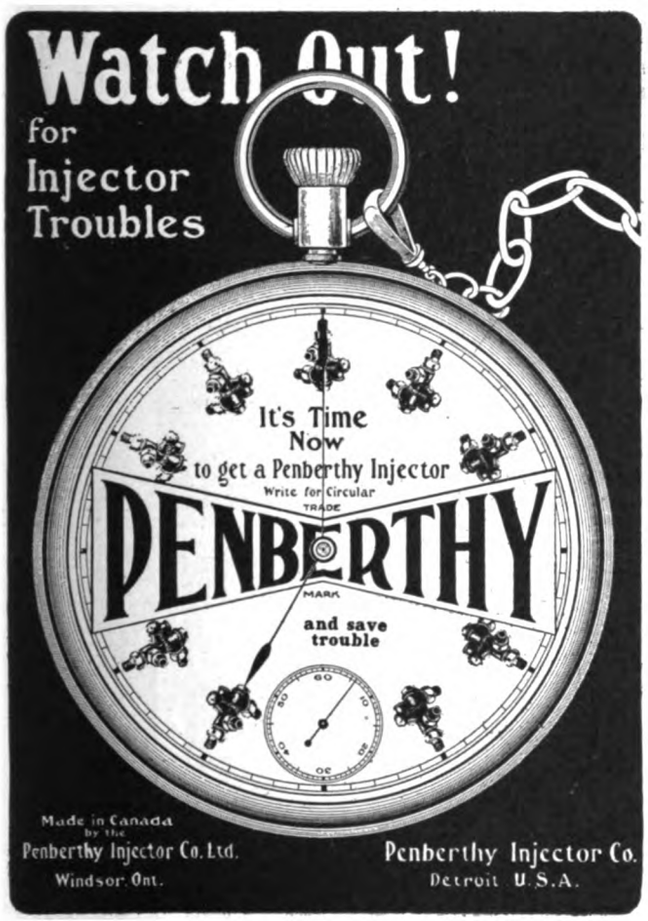

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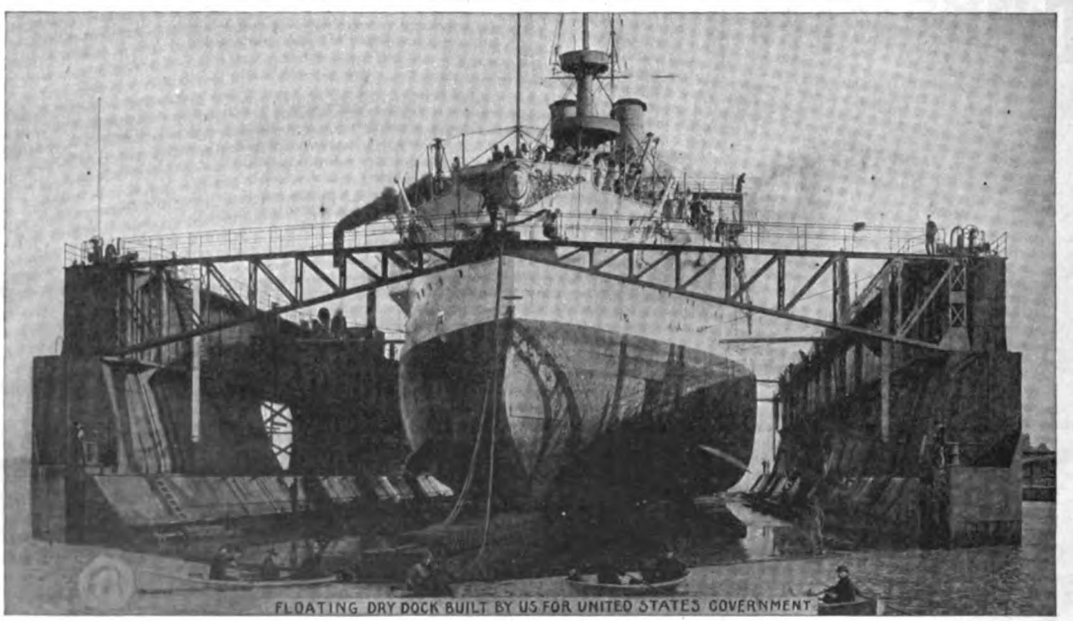

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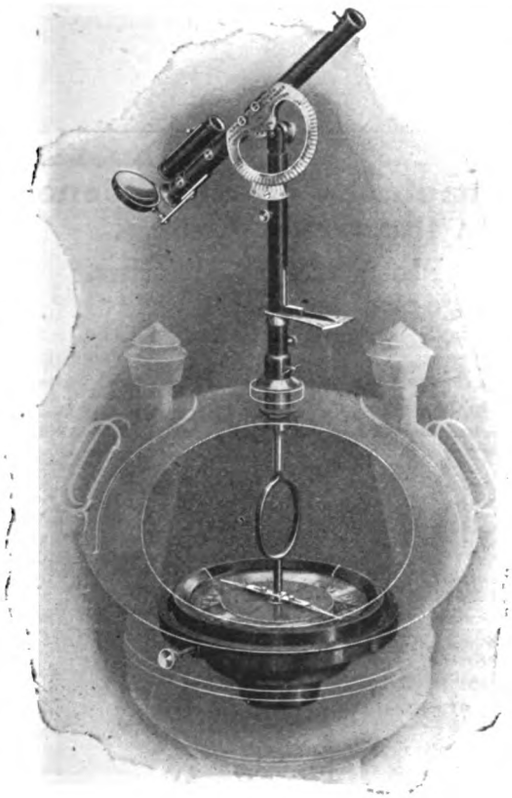

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Mohawk.
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Poe Lock, from above.
Poe Lock, with Whaleback.
Whaleback Str. Pathfinder in the Locks.
St. Marys River, South from the Locks.
Weitzel Lock, from above.
Weitzel Lock, from below.
Str. North Land Passing Locks, two views.
Upper Entrance to Lock Canal.
Gate Mechanism.
Interior of Power House.
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Canadian Lock from Lower End.
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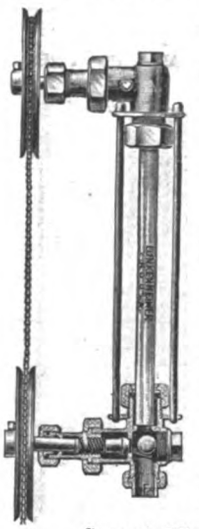

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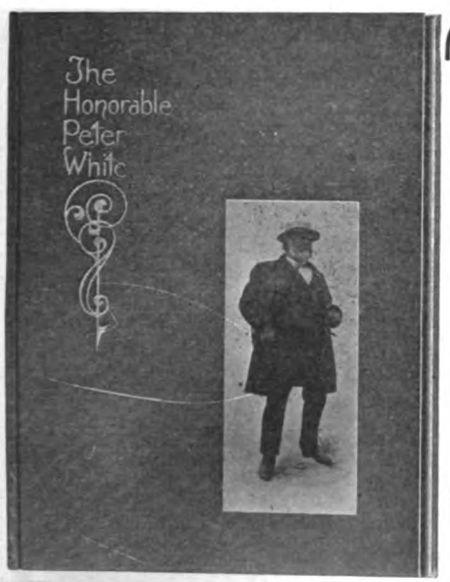

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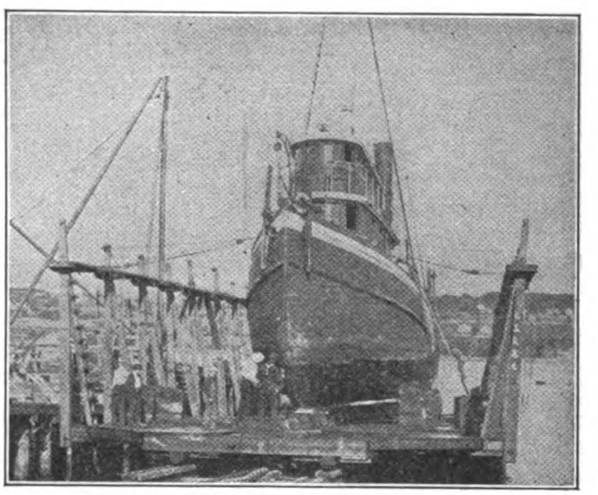

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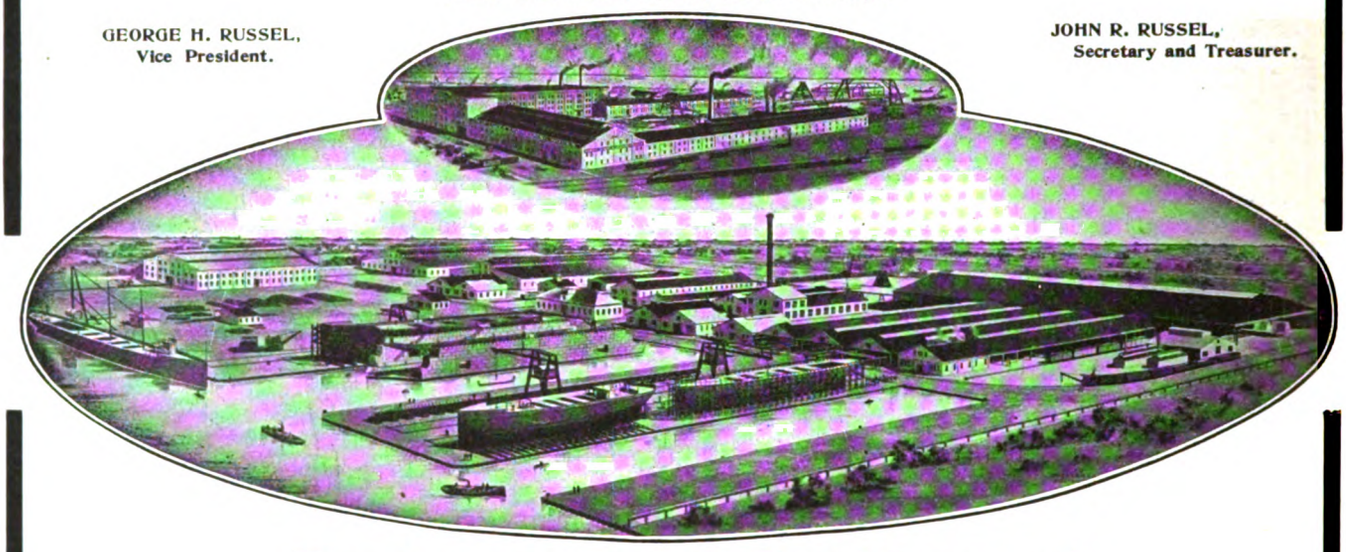

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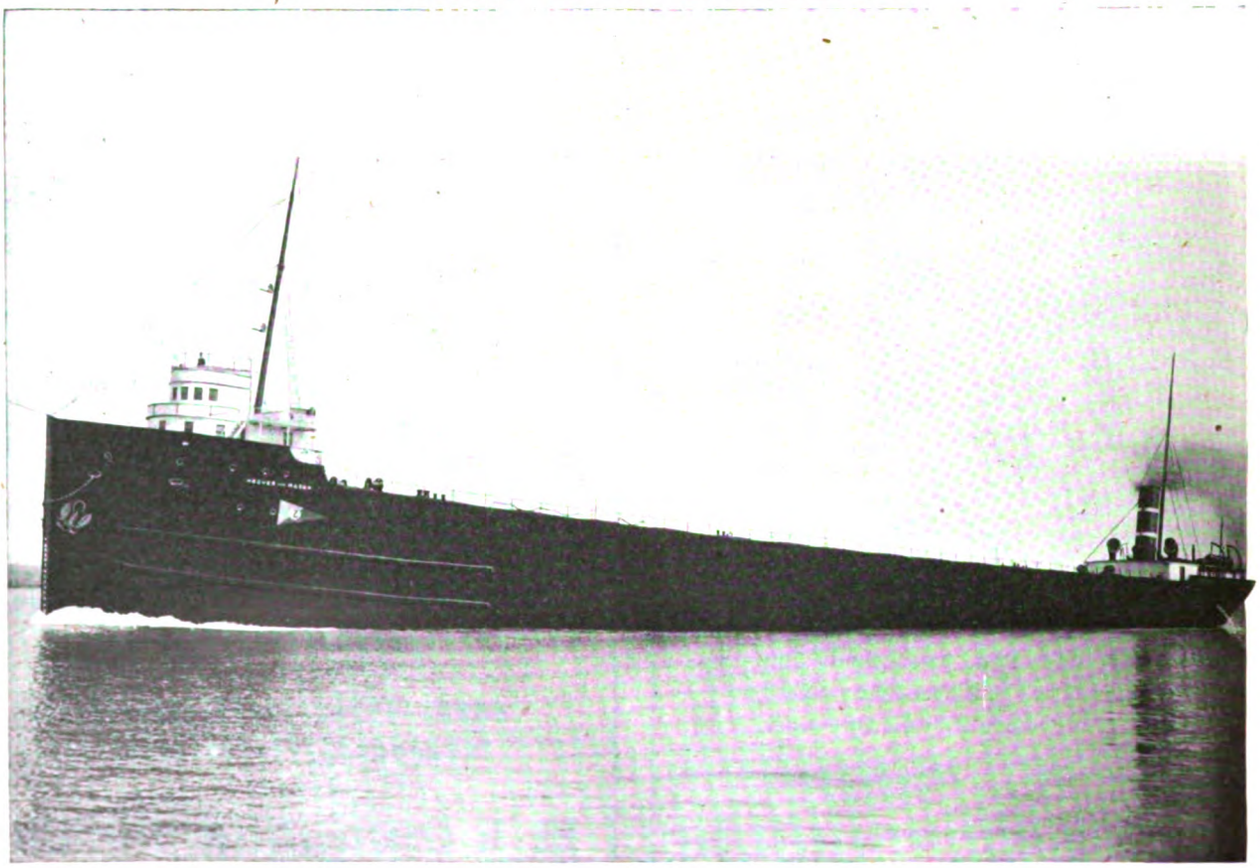

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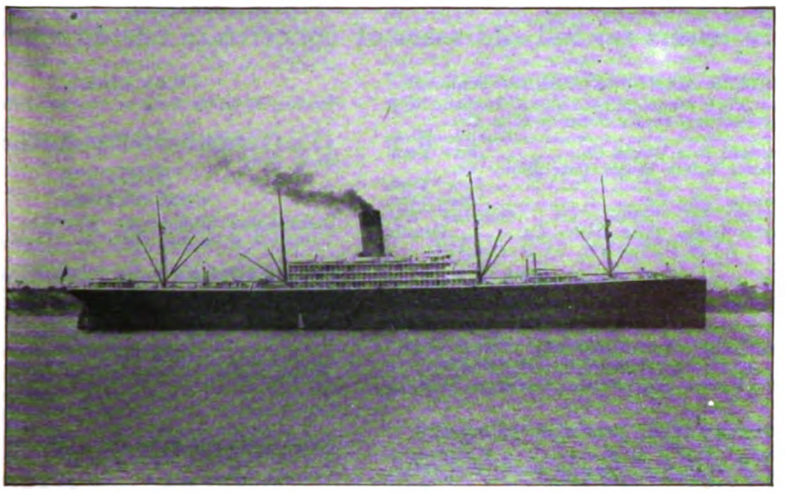

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See accompanying index of Advertisers for full addresses of concerns in this directory.

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Great Lakes Engineering Works.....Detroit.
Mietz, Aug. .....New York.

AIR PORTS, DEAD LIGHTS, ETC.
Marine Mfg. & Supply Co.....New York.

AIR PUMPS AND APPLIANCES.
Fore River Ship & Engine Co..Quincy, Mass.
Great Lakes Engineering Works.....Detroit.

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Detroit Ship Building Co.....Detroit
Great Lakes Engineering Works.....Detroit
Sturtevant, B. F., Co.....Hyde Park, Mass.

ASH EJECTORS.
Great Lakes Engineering Works.....Detroit.

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Jenkins, Russell & Eichelberger....Cleveland.
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MacDonald, Ray G.....Chicago.
Shaw, Warren, Cady & Oakes.....Detroit.
White, Johnson, McCaslin & Cannon Cleveland

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Cleveland Block Co.....Cleveland.

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Power Specialty Co.....Detroit.
Sturtevant, B. F. Co.....Hyde Park, Mass.

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Drein, Thos. & Son.....Wilmington, Del.
Kahnweiler's Sons, David.....New York.
Lane & DeGroot....Long Island City, N. Y.
Marine Construction & D. D. Co.....
.....Mariner's Harbor, S. I., N. Y.
Truscott Boat Mfg. Co.....St. Joseph, Mich.
Willard, Chas. P. & Co. Winthrop Harbor, Ill.

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Power Specialty Co.....Detroit.

BOILER COMPOUNDS.
The Bird-Archer Co..... New York
Dearborn Drug & Chemical Works....Chicago.

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Atlantic Works.....East Boston, Mass.
Chicago Ship Building Co.....Chicago.
Cramp, Wm. & Sons.....Philadelphia.
Dearing Water Tube Boiler Co.....Detroit.
Detroit Ship Building Co.....Detroit.
East End Boiler Works.....Detroit.
Fletcher, W. A. & Co.....Hoboken, N. J.
Fore River Shipbuilding Co.....Quincy, Mass.
Great Lakes Engineering Works.....Detroit.
Kingsford Foundry & Machine Works....
.....Oswego, N. Y.
Marine Iron Works.....Chicago.
Maryland Steel Co.....Sparrows Point, Md.
Milwaukee Dry Dock Co.....Milwaukee.
Mosher Water Tube Boiler Co....New York.
Newport News Ship Building Co.....
.....Newport News, Va.

BOILER MANUFACTURERS—Continued.
New York Shipbuilding Co.....Camden, N. J.
Northwestern Steam Boiler & Mfg. Co....
.....Duluth, Minn.
Quintard Iron Works Co.....New York.
Roberts Safety Water Tube Boiler Co....
.....New York.
Stirling, The Co....., New York.
Superior Ship Building Co.....Superior, Wis.
Taylor Water Tube Boiler Co.....Detroit.

BOILER RIVETS.
Bourne-Fuller Co.....Cleveland.

BOILER STAYBOLTS, IRON OR STEEL, HOLLOW OR SOLID.
Falls Hollow Staybolt Co..Cuyahoga Falls, O.

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Cramp, Wm. & Sons.....Philadelphia.
Fore River Ship & Engine Co..Quincy, Mass.
Great Lakes Engineering Works.....Detroit.
Lunkenheimer Co.....Cincinnati.
Macbeth Iron Co.....Cleveland.

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Cowing, John P.....Cleveland.
Scherzer Rolling Lift Bridge Co.....Chicago.

BUCKETS, ORE AND COAL.
Brown Hoisting & Conveying Machine Co.
..... Cleveland.

BULKHEAD DOORS, WATERTIGHT.
"Long Arm" System Co.....Cleveland.

CABIN AND CABINET FINISHING WOODS.
Martin-Barriss Co.....Cleveland.

CANVAS SPECIALTIES.
Baker & Co., H. H.....Buffalo.
Bunker, E. A. .....New York.
Upson-Walton Co.....Cleveland.

CAPSTANS.
American Ship Windlass Co..Providence, R. I.
Hyde Windlass Co.....Bath, Me.
Marine Mfg. & Supply Co.....New York.

CEMENT, IRON FOR REPAIRING LEAKS.
Smooth-On Mfg. Co.....Jersey City, N. J.

CHAINS.
Woodhouse Chain Works.....Trenton, N. J.

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Brown Hoisting Machinery Co. (Inc.)....
..... Cleveland.
General Electric Co.....Schenectady, N. Y.

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Boston & Lockport Block Co....Boston, Mass.

CHARTS.
Penton Publishing Co.....Cleveland.
Potter, J. D.....London.

CLOCKS (Marine and Ship's Bell) AND CHRONOMETERS.
Ashton Valve Co.....Boston.
Ritchie, E. S. & Sons.....Brookline, Mass.

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Hanna, M. A. & Co.....Cleveland.
Ironville Dock & Coal Co.....Toledo, O.
Pickands, Mather & Co.....Cleveland.
Pittsburg Coal Co.....Cleveland.

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Brown Hoisting Machinery Co. (Inc.)....
..... Cleveland.

COMPASSES.
Ritchie, E. S. & Sons.....Brookline, Mass.

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How, Benj. V..... Boston

CONDENSERS.
Great Lakes Engineering Works.....Detroit.
Thropp & Sons Co., John E...Trenton, N. J.

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Dunbar & Sullivan Dredging Co.....Buffalo.
Fitz-Simons & Connell Co.....Chicago.
Great Lakes Dredge & Dock Co.....Chicago.
Hickler Bros.....Sault Ste. Marie, Mich.
Hubbell Co., H. W.....Saginaw, Mich.
Lake Superior Contracting & Dredging Co.,
..... Duluth, Minn.
Smith Co., L. P. & J. A.....Cleveland.
Starke Dredge & Dock Co., C. H..Milwaukee.
Sullivan, M.....Detroit.

CORDAGE.
Baker & Co., H. H.....Buffalo.
Upson-Walton Co.....Cleveland.

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Armstrong Cork Co.....Pittsburg, Pa.
Kahnweiler's Sons, D.....New York.

CRANES, TRAVELING.
Brown Hoisting Machinery Co.....Cleveland.

DIVING APPARATUS.
Morse, A. J. & Son.....Boston.
Schrader's Son, Inc., A..... ... New York.

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Sturtevant Co., B. F.....Hyde Park, Mass

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Breymann & Bros., G. H.....Toledo.
Buffalo Dredging Co.....Buffalo.
Dunbar & Sullivan Dredging Co.....Buffalo.
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DREDGING MACHINERY.
Quintard Iron Works Co.....New York.

DRYING APPARATUS.
Sturtevant, B. F. Co.....Hyde Park, Mass.

DRY DOCKS.
American Ship Building Co.....Cleveland.
Atlantic Works.....East Boston, Mass.
Buffalo Dry Dock Co.....Buffalo.
Chicago Ship Building Co.....Chicago.
Craig Ship Building Co.....Toledo, O.
Cramp, Wm. & Sons.....Philadelphia.
Detroit Ship Building Co.....Detroit.
Great Lakes Engineering Works.....Detroit.
Lockwood Mfg. Co.....East Boston, Mass.
Milwaukee Dry Dock Co.....Milwaukee.
Newport News Ship Building Co.....
.....Newport News, Va.
Shipowners Dry Dock Co.....Chicago.
Superior Ship Building Co....Superior, Wis.
Tietjen & Lang Dry Dock Co....Hoboken, N. J

DREDGE BUILDERS.
Manitowoc Dry Dock Co.....Manitowoc, Wis.

DYNAMOS.
General Electric Co.....Schenectady, N. Y
Mietz, Aug.....New York.
Sturtevant, B. F. & Co.....Hyde Park, Mass.
Thropp & Sons, John E.....Trenton, N. J.

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Sturtevant Co., B. F.....Hyde Park, Mass.

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Thropp & Sons, John E.....Trenton, N. J.

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Chicago Ship Building Co.....Chicago.
Chase Machine Co.....Cleveland.
Cramp, Wm. & Sons.....Philadelphia.
Craig Ship Building Co.....Toledo, O.
Detroit Ship Building Co.....Detroit.
Fletcher, W. & A. Co.....Hoboken, N. J.
Fore River Shipbuilding Co....Quincy, Mass.
Great Lakes Engineering Works.Detroit, Mich.
Hall Bros. .....Philadelphia.
Lockwood Mfg. Co.....East Boston, Mass.
Maryland Steel Co.....Sparrows Point, Md.
Mietz, Aug.....New York.
Milwaukee Dry Dock Co.....Milwaukee.
Mosher, Chas. D.....New York.
Moulton Steering Engine Co.....New York.
Newport News Ship Building Co.....
.....Newport News, Va.
New York Shipbuilding Co....Camden, N. J.
Northwestern Steam Boiler & Mfg. Co...
..... Duluth, Mich.
Quintard Iron Works Co.....New York.
Roach's Ship Yard.....Chester, Pa.
Sheriffs Mfg. Co.....Milwaukee.
Superior Ship Building Co....Superior, Wis.
Thropp, J. E. & Sons Co.....Trenton, N. J.
Trout, H. G.....Buffalo.

ENGINE BUILDERS, STEAM.

Sturtevant Co., B. F.....Hyde Park, Mass.

ENGINE ROOM TELEGRAPH, CALL BELLS, ETC.

Cory, Chas. & Son.....New York.
Marine Mfg. Supply Co.....New York.

ENGINEERING SPECIALTIES AND SUPPLIES.

Kieley & Mueller .....New York.
Lunkenheimer Co. .....Cincinnati.
Northwestern Steam Boiler & Mfg. Co...
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Kidd, Joseph.....Duluth, Minn.
Mosher, Chas. D.....New York.
Nacey, James .....Cleveland.
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Wood, W. J. .....Chicago.

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Ross Valve Co.....Troy, N. Y.

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Safety Fire Extinguisher Co.....New York.

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Cleveland City Forge & Iron Co...Cleveland.
Fore River Shipbuilding Co.....Quincy, Mass.
Macbeth Iron Co.....Cleveland.

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Fix's, S. Sons.....Cleveland.

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Pittsburg Coal Co.....Cleveland.
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Continental Iron Works.....New York.

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Safety Car Heating & Lighting Co..New York.

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Lunkenheimer Co. .....Cincinnati.

GAUGES, WATER.

Bonner Co., Wm. T.....Boston.
Lunkenheimer Co. .....Cincinnati, O.

GENERATING SETS.

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General Electric Co.....Schenectady, N. Y.

GRAPHITE.

Dixon Crucible Co., Joseph..Jersey City, N. J

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.....Perth Amboy, N. J.

HAMMERS, STEAM.

Chase Machine Co.....Cleveland.

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Brown Hoisting Machinery Co. (Inc.).....
..... Cleveland.
Chase Machine Co.....Cleveland.
General Electric Co.....New York.
Georgian Bay Engineering Works.....
.....Midland, Ont.
Hyde Windlass Co.....Bath, Me.
McMyler Mfg. Co.....Cleveland.
Marine Iron Co.....Bay City.
Mietz, Aug. .....New York.

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HOLLOW STAYBOLT IRON.

Falls Hollow Staybolt Co...Cuyahoga Falls, O.

HYDRAULIC DREDGES.

Great Lakes Engineering Works.....Detroit.

HYDRAU. IC TOOLS.

Watson-Stillman Co., The.....New York.

ICE MACHINERY.

Great Lakes Engineering Works.....Detroit.
Roelker, H. B.....New York.

INDICATORS FOR STEAM ENGINES.

Ashton Valve Co.....Boston.

INJECTORS.

American Injector Co.....Detroit.
Jenkins Bros. .....New York.
Lunkenheimer Co.....Cincinnati.
Penberthy Injector Co.....Detroit, Mich.

INSURANCE, MARINE.

Elphicke, C. W. & Co.....Chicago.
Fleming & Co., E. J.....Chicago.
Gilchrist & Co., C. P.....Cleveland.
Hawgood & Co., W. A.....Cleveland.
Helm & Co., D. T.....Duluth.
Hutchinson & Co.....Cleveland.
McCarthy, T. R.....Montreal.
McCurdy, Geo. L.....Chicago.
Mitchell & Co.....Cleveland.
Parker Bros. Co., Ltd.....Detroit.
Peck, Chas. E. & W. F..New York & Chicago.
Prindiville & Co.....Chicago.
Richardson, W. C.....Cleveland.
Sullivan, D. & Co.....Chicago.

IRON CASTINGS.

Sutton Co., C. E.....Toledo, O.

IRON ORE AND PIG IRON.

Bourne-Fuller Co.....Cleveland, O.
Hanna, M. A. & Co.....Cleveland.
Pickands, Mather & Co.....Cleveland.

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Marine Iron Works.....Chicago.
Truscott Boat Mfg. Co.....St. Joseph, Mich.

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Armstrong, Cork Co.....Pittsburg.
Drein, Thos. & Son.....Wilmington, Del.
Kahnweiler's Sons, D.....New York.

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Russell & Watson .....Buffalo.

LOGS.

Nicholson Ship Log Co.....Cleveland.
Walker & Sons, Thomas....Birmingham, Eng.
Also Ship Chandlers.

LUBRICATING GRAPHITE.

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Lunkenheimer Co. .....Cincinnati

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Martin-Barriss Co.....Cleveland.
Rayher, J. .....Chicago.

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Chase Machine Co.....Cleveland.
Hickler Bros.....Sault Ste. Marie, Mich.
Lockwood Mfg. Co.....East Boston, Mass.

MACHINE TOOLS (WOOD WORKING).

Atlantic Works, Inc.....Philadelphia.

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Hickler Bros.....Sault Ste. Marie, Mich.

MARINE RAILWAYS, BUILDERS OF.

Crandall & Son, H. I.....East Boston, Mass.

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Fogg, M. W.....New York.

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Detroit Ship Building Co.....Detroit.
Great Lakes Engineering Works.....Detroit.
Sturtevant, B. F. Co.....Hyde Park, Mass.

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General Electric Co.....Schenectady, N. Y.
Sturtevant, B. F. Co.....Hyde Park, Mass.

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Benjamin Farnum How.....Boston
Ritchie, E. S., & Sons.....Brookline, Mass.

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Hynd, Alexander .....Cleveland.
Kidd, Joseph .....Duluth, Minn.
Mosher, Chas. D.....New York.
Nacey, James .....Cleveland.
Wood, W. J. .....Chicago.

OAKUM.

Stratford, Oakum Co.....Jersey City, N. J.

OIL ENGINES.

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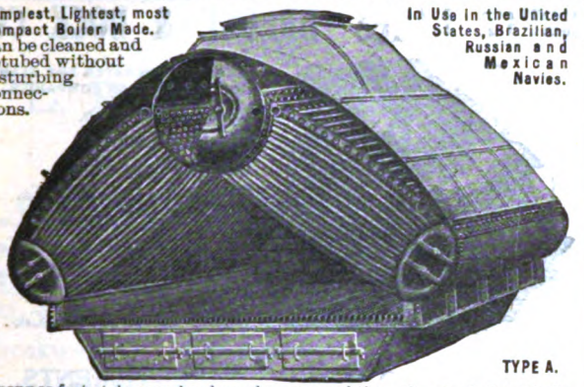

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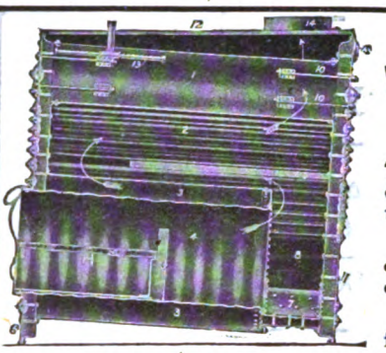

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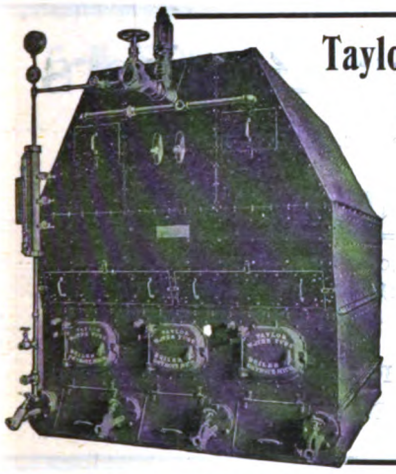

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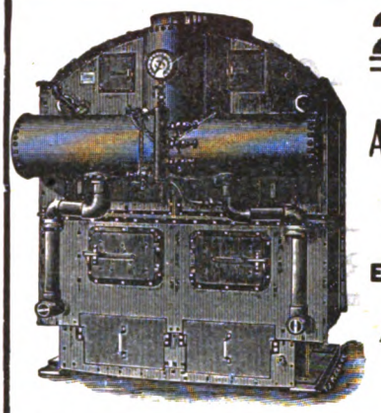

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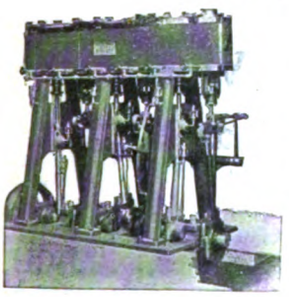

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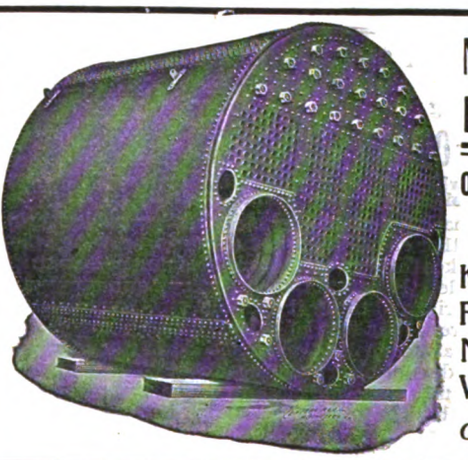

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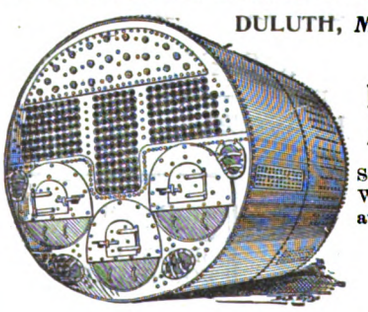

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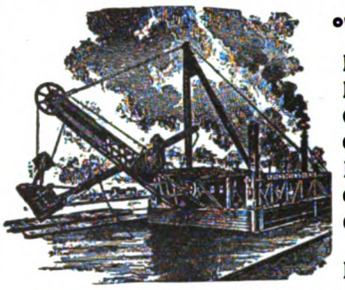

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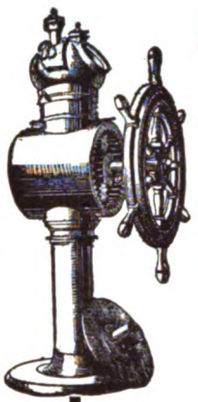

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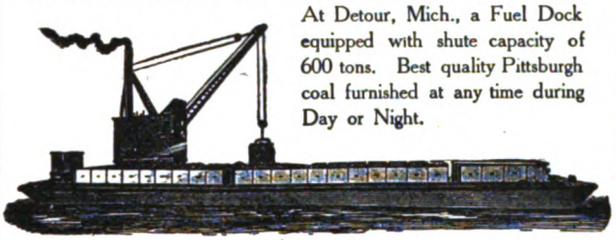

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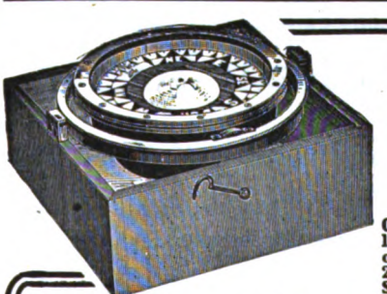

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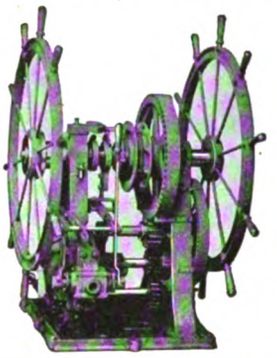

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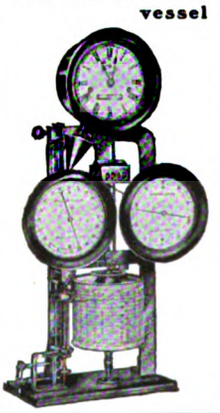

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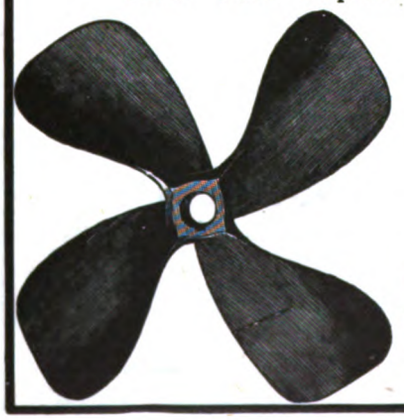

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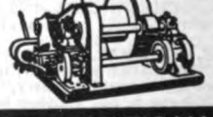

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CLEVELAND

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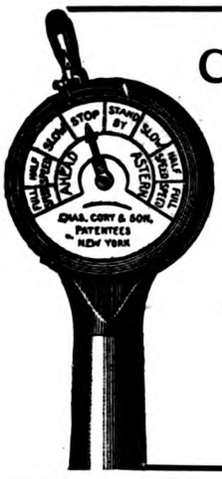

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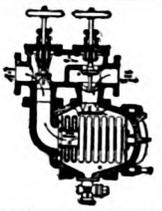

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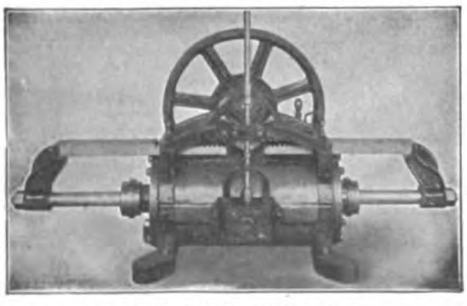

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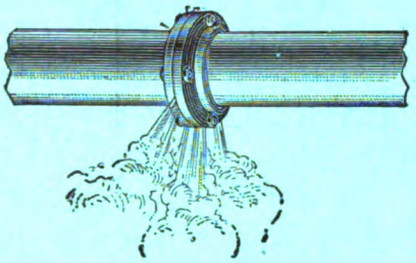

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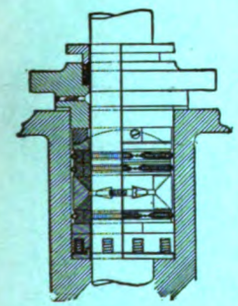

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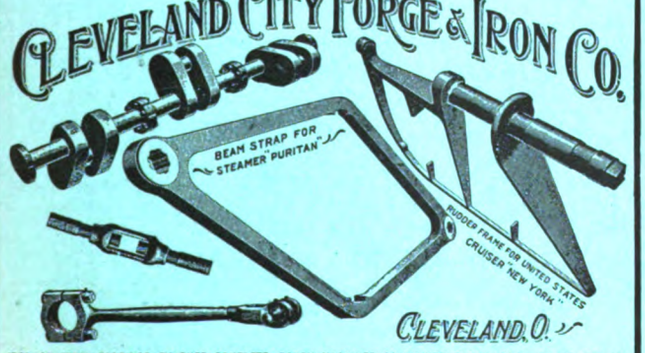

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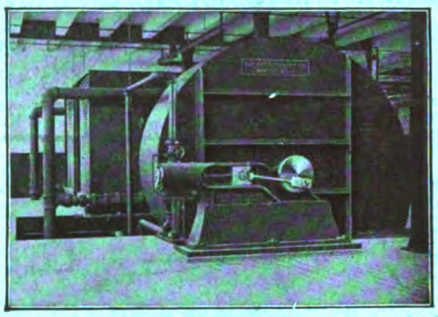

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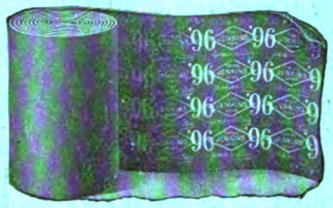

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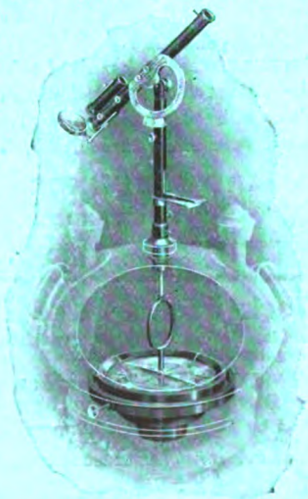

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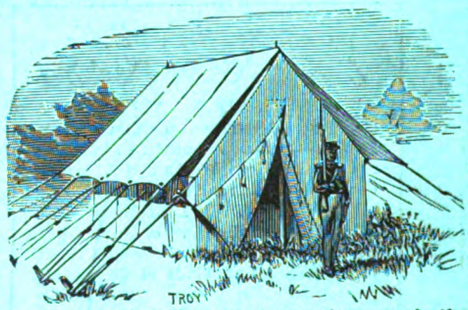

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